

# The AMSAT Journal

Volume 16 No. 3  
May/June 1993



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## Ground Station Tracking Via Packet

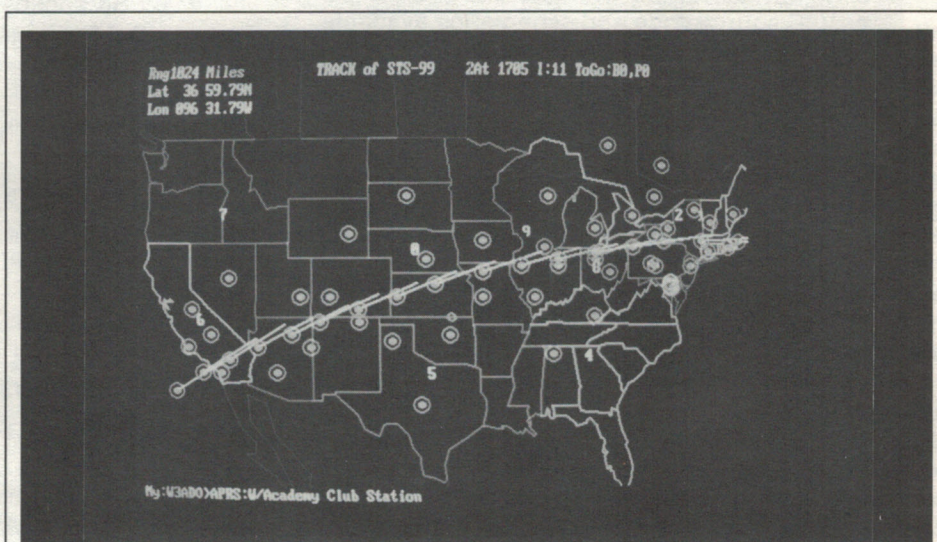
By: Bob Bruninga, WB4APR

### Abstract

The following article proposes to exploit a new facet of packet radio which diverges from the historical message text capability into geolocation. Instead of presenting a text/message screen to the users, the main system presentations are maps. Maps can be any scale from the whole USA for HF and satellite operations, down to 1 mile square for local public ser-

vice events. Users may still exchange short message lines, but the real advantages of the system is the tactical display of all station and object locations. Any user in the network can place objects on his map for immediate display on all other stations maps. In this manner, anything from runners, to bicycles, cars, boats, and emergency vehicles can be tracked. In addition,

(continued on page 8)



This photo shows the APRS display of a simulated track of the Space Shuttle across the US sending its GPS position about every two minutes. All stations who are beaconing their LAT.LONG and were digipeated by the SAREX show up in real time. Callsigns have been suppressed to keep the picture uncluttered.

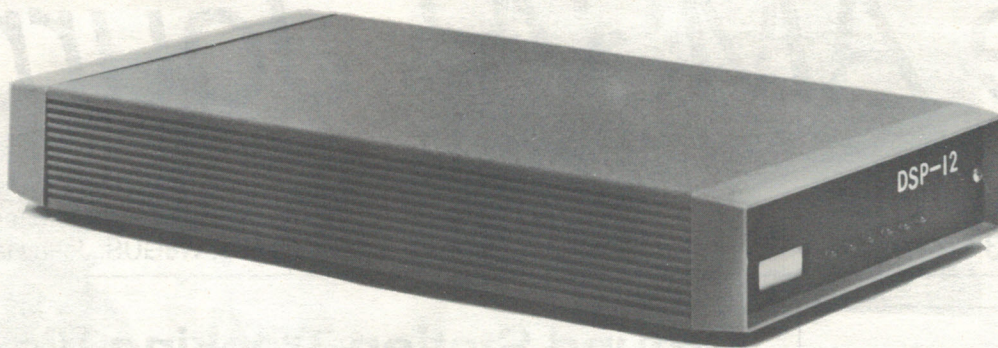
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70413.3525

**Production Office:** Executive Printing Services,  
Inc., 6640 Ammendale Rd. Beltsville, MD 20705

**Advertising Office:** AMSAT Headquarters, 850  
Sligo Avenue, Silver Spring, MD 20910-4703

**AMSAT-NA Headquarters:** 850 Sligo Ave., Silver  
Spring, MD 20910-4703 Telephone: 301-589-  
6062 (10 AM to 6 PM Eastern). FAX 301-608-3410

*The AMSAT Journal* (ISSN:1047-3076) is pub-  
lished bi-monthly (Jan, Mar, May, July, Sept, Nov)  
by AMSAT-NA, 850 Sligo Ave., Silver Spring, MD  
20910-4703 Telephone: 301-589-6062. Second  
Class postage paid at Silver Spring, MD and addi-  
tional mailing offices. Postmaster: send address  
changes to *The AMSAT Journal*, 850 Sligo Ave.,  
Silver Spring, MD 20910-4703

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## Mode B on Phase 3D!

**By: Bill Tynan, W3XO**  
*President AMSAT-NA*

A lot has been heard recently regarding "Mode B" on Phase 3D. At least two elec-  
tronic mail bulletins reporting on a meet-  
ing held near Munich in mid-April  
seemed quite explicit in stating that the  
new spacecraft would NOT contain a 2  
meter transmitter. It goes without saying  
that it's pretty hard to have what we call  
Mode B if you don't have a 2 meter trans-  
mitter on the satellite.

However, things are not always what  
they seem. The meeting in question was  
strictly an engineering meeting, NOT one  
constituted to make overall management  
decisions. On the other hand, it was very  
important in that, for the first time, partic-  
ular individuals and groups were identi-  
fied that would commit to supplying spe-  
cific pieces of hardware. As has been said  
repeatedly, in past Apogee Views; all of  
the AMSAT groups are almost entirely  
staffed by volunteers. All of the technical  
work is done by volunteers. That's why it  
is often difficult to get specific commit-  
ments from people who may have jobs  
and families which must take priority  
over things they might like to do for ham  
radio. Once they do find time to do some-  
thing for ham radio, they understandably  
want to have a say in what it is. Would  
you volunteer to take on a job which  
might require a year of your life and sub-  
stantially eat into time you might spend  
on other pursuits, if the task isn't interest-  
ing to you and perhaps you don't believe  
in it?

That's the sort of dilemma we face in  
providing a 2 meter transmitter for Phase  
3D. Originally, it was to be built in  
Germany. But recent events, including the  
increasing interference on the 2 meter  
satellite segment from 145.8 to 146.0 MHz,  
has caused the Germans, who might take  
on the project, to lose interest in it. They  
have proposed, instead, to build a 70 cm  
(435 MHz) transmitter and a 2 meter  
receiver. Coupled together, through the IF  
matrix, these form what we now know as  
Mode J. They contend, that Mode J is the  
equivalent of Mode B because it employs  
basically the same ground station equip-  
ment. Most of us use one of the satellite  
transceivers such as the Yaesu FT-736,

Kenwood TS-790 or Icom IC-970; or sepa-  
rate transceivers for 2 meters and 70 cm. A  
few may use equipment which includes a  
70 cm transmitter but no receiver and a 2  
meter receiver but no transmitter. The  
Ten-Tec Model 2510 is one example of  
such a rig. But, the stations of the vast  
majority of Mode B users can also be used  
for Mode J.

Then why is Mode J less popular than  
Mode B? First, of course, Mode B is ON  
more on OSCAR-13; and doesn't exist at  
all on OSCAR-10. Another factor, possibly  
contributing to Mode J's lower use, is the  
fact that there are fewer Europeans on it.  
Europeans make up a large proportion of  
the Mode B activity and many find them  
interesting to talk to, so their very pres-  
ence generates activity in this part of the  
world. I believe that one reason Euro-  
peans do not frequent Mode J as much as  
they do Mode-B, has to do with the specifi-  
c band segment chosen for the uplink, i.e.  
144.425 - 144.475. In Europe, the recog-  
nized band plan follows that suggested by  
the IARU which provides for terrestrial  
SSB and CW operation from 144.0 to 144.5  
MHz. Satellite operation is not included  
on that portion of the band. In fact, follow-  
ing the launch of AO-13 a "Recommend-  
ation" was ratified by IARU stating;

"As the IARU Region 1 144-146 MHz  
bandplan contains no provision for satel-  
lite communication in the lower part of  
the 144-146 MHz band. It is recommended  
that the mode J transponder in Oscar 13  
not be used by amateurs in region 1. If  
member societies would report serious  
interference to terrestrial communications  
from the non-recommended use of the  
satellite transponder, IARU recommends  
that the mode J transponder in Oscar 13  
be permanently switched to "OFF".

In this country, the ARRL Band Plan  
also designates this same segment for SSB  
and CW, but, following a recommenda-  
tion by AMSAT-NA, also includes a pro-  
vision for satellite operation. However,  
with the possible exception of a few mete-  
or scatter schedules, frequencies much  
above 144.30 have seen little use for SSB  
and CW operation in North America. In

(continued on page 7)



# A Satellite Mode S Loop Yagi Antenna

By: Ed Krome, KA9LNV

In the March/April 1993 issue of The AMSAT Journal, I was pleased to see an excellent article by James Miller G3RUH on the construction and use of a 60cm dish antenna for satellite Mode S reception. Now I'm going to have to build one to try it! (My wife never did think much of the 12 foot dish I ALMOST planted in the backyard. Maybe she will like this one better.) The following article is an alternate approach to S band reception. I have been using the described antenna for several years and have found it satisfactory.

## Background

This loop yagi design is based on a paper presented by Joe Reisert W1JR at the first annual 1296/2304 Conference (19-22 September 1985, in Estes Park, Colorado) and detailed in the Conference proceedings. W1JR's work was based on earlier original work by Mike Walters G3JVL. This innovative antenna design replaces the near-half wavelength rods of a common yagi with near-full wave loops. Conventional yagi designs for 13cm have never been popular homebrew projects because of the extremely small length tolerance requirements. The use of full wave loops eases this requirement to a level that makes home duplication reasonable. The resulting antenna described here is extremely small, light and easy to mount.

For additional information on loop yagis (and construction hints), see the latest edition of The ARRL Handbook for Radio Amateurs under "UHF and Microwave Equipment".

## Construction

W1JR's design was for 2304 MHz. Since loop yagis are known to have low pass filter characteristics and I wanted to use the antenna on both 2304 and 2401, I did the unpardonable and scaled element lengths to 2350 MHz. I did not change the element spacing.

The antenna has 52 elements and fits on an 8' section of 1/2" diameter aluminum tubing. Element lengths and spacing are itemized in Table 1. All dimensions are important; for best results the antenna should be duplicated as closely as possible.

## Elements

The elements are fabricated from 1/4 inch wide strips of .032" thick aluminum, except for the driven element, which is

Table 1 2304/2401 MHz Loop Yagi

| Element | Spacing from rear<br>(Original 2304 MHz) |        | Circumference<br>(Original 2304 MHz) | Circumference<br>(Scaled to 2350 MHz) |
|---------|------------------------------------------|--------|--------------------------------------|---------------------------------------|
|         | (inches)                                 | (cm)   | (inches)                             | (inches)                              |
| R2      | 1.000                                    | 2.54   | 5.480                                | 5.373                                 |
| R1      | 2.744                                    | 6.97   | 5.480                                | 5.373                                 |
| DE      | 3.278                                    | 8.33   | 5.125                                | 5.025                                 |
| D1      | 3.908                                    | 9.93   | 4.676                                | 4.584                                 |
| D2      | 4.375                                    | 11.11  | 4.676                                | 4.584                                 |
| D3      | 5.376                                    | 13.66  | 4.676                                | 4.584                                 |
| D4      | 6.378                                    | 16.20  | 4.676                                | 4.584                                 |
| D5      | 7.081                                    | 17.99  | 4.676                                | 4.584                                 |
| D6      | 8.380                                    | 21.29  | 4.676                                | 4.584                                 |
| D7      | 10.383                                   | 26.37  | 4.676                                | 4.584                                 |
| D8      | 12.385                                   | 31.46  | 4.676                                | 4.584                                 |
| D9      | 14.388                                   | 36.55  | 4.676                                | 4.584                                 |
| D10     | 16.390                                   | 41.63  | 4.676                                | 4.584                                 |
| D11     | 18.393                                   | 46.72  | 4.676                                | 4.584                                 |
| D12     | 20.395                                   | 51.80  | 4.534                                | 4.445                                 |
| D13     | 22.398                                   | 56.89  | 4.534                                | 4.445                                 |
| D14     | 24.400                                   | 61.98  | 4.534                                | 4.445                                 |
| D15     | 26.403                                   | 67.06  | 4.534                                | 4.445                                 |
| D16     | 28.405                                   | 72.15  | 4.534                                | 4.445                                 |
| D17     | 30.408                                   | 77.24  | 4.534                                | 4.445                                 |
| D18     | 32.410                                   | 82.32  | 4.392                                | 4.306                                 |
| D19     | 34.413                                   | 87.41  | 4.392                                | 4.306                                 |
| D20     | 36.415                                   | 92.49  | 4.392                                | 4.306                                 |
| D21     | 38.418                                   | 97.58  | 4.392                                | 4.306                                 |
| D22     | 40.420                                   | 102.67 | 4.392                                | 4.306                                 |
| D23     | 42.423                                   | 107.75 | 4.392                                | 4.306                                 |
| D24     | 44.425                                   | 112.84 | 4.335                                | 4.250                                 |
| D25     | 46.428                                   | 117.93 | 4.335                                | 4.250                                 |
| D26     | 48.430                                   | 123.01 | 4.335                                | 4.250                                 |
| D27     | 50.433                                   | 128.10 | 4.335                                | 4.250                                 |
| D28     | 52.435                                   | 133.18 | 4.335                                | 4.250                                 |
| D29     | 54.438                                   | 138.27 | 4.335                                | 4.250                                 |
| D30     | 56.440                                   | 143.36 | 4.335                                | 4.250                                 |
| D31     | 58.443                                   | 148.45 | 4.335                                | 4.250                                 |
| D32     | 60.445                                   | 153.53 | 4.335                                | 4.250                                 |
| D33     | 62.448                                   | 158.62 | 4.335                                | 4.250                                 |
| D34     | 64.450                                   | 163.70 | 4.335                                | 4.250                                 |
| D35     | 66.453                                   | 168.79 | 4.335                                | 4.250                                 |
| D36     | 68.455                                   | 173.88 | 4.279                                | 4.195                                 |
| D37     | 70.458                                   | 178.96 | 4.279                                | 4.195                                 |
| D38     | 72.460                                   | 184.05 | 4.279                                | 4.195                                 |
| D39     | 74.463                                   | 189.14 | 4.279                                | 4.195                                 |
| D40     | 76.465                                   | 194.22 | 4.279                                | 4.195                                 |
| D41     | 78.468                                   | 199.31 | 4.279                                | 4.195                                 |
| D42     | 80.470                                   | 204.39 | 4.279                                | 4.195                                 |
| D43     | 82.473                                   | 209.48 | 4.229                                | 4.146                                 |
| D44     | 84.475                                   | 214.57 | 4.229                                | 4.146                                 |
| D45     | 86.478                                   | 219.65 | 4.229                                | 4.146                                 |
| D46     | 88.480                                   | 224.74 | 4.229                                | 4.146                                 |
| D47     | 90.483                                   | 229.83 | 4.229                                | 4.146                                 |
| D48     | 92.485                                   | 234.91 | 4.229                                | 4.146                                 |
| D49     | 94.488                                   | 240.00 | 4.229                                | 4.146                                 |

Boom: 8' length of 1/2" diameter aluminum tubing (do not use anodized tubing).

Elements: All parasitic elements are made from aluminum strips 0.25" wide by 0.032" thick. The driven element is 0.25" x .032" brass strip.

Circumference: Distance between centers of 0.116" holes drilled in each element. Tolerance +/- 0.005". Each element is to be made approximately 3/8" longer than the specified circumference dimension to allow approximately 3/16" overlap between the ends of the element.



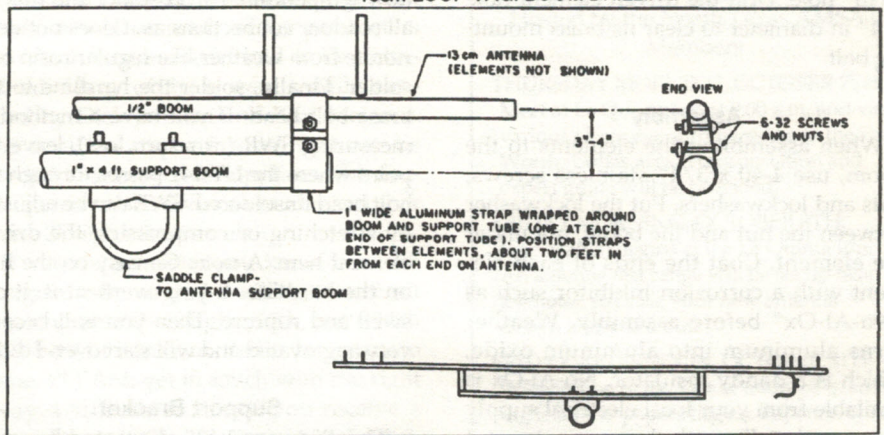
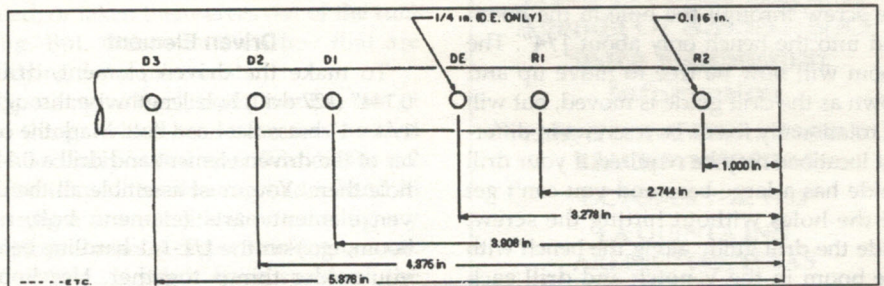
made from 1/4" x .032 brass strip. One method of making the elements is to first prepare element stock by having a sheet metal shop shear a bunch of 1/4" wide strips about 2' long from a sheet of 0.032" thick aluminum. Do not use anodized aluminum for the elements or the boom.

Adjust a pair of dividers with steel scribe points to the desired length with a vernier caliper. We want about 3/16" overlap between the ends of each loop element, so for the first element marked on each aluminum strip, set one leg of the (preset) dividers about 3/16" in from the end of the strip. Then set the divider point and scribe off the specified length. Recheck each dimension. Tolerances should be held to +/- .005" so be careful. Then measure 3/16" from the center of the second mark and scribe a line across the aluminum strip to indicate the end of that particular element. Then measure about 3/16" from the "end of element (cutoff)" mark and repeat the whole process of marking element hole spacing. The elements will be cut apart later, as it is easier to handle a whole strip than a bunch of short pieces. After you scribe a pair of hole locations, mark the element number on it with a waterproof marker. Then, with a magnifying glass, center punch each mark accurately. Drill each hole 0.116" (#32 drill) in diameter. Drill one hole at a time; stacking strips is a sure way to goof. Deburr each hole. Finally, cut the element strips apart with a tin snips. Preform each element loop by bending it around a form, such as a piece of 3/4" PVC pipe, to set the circular shape.

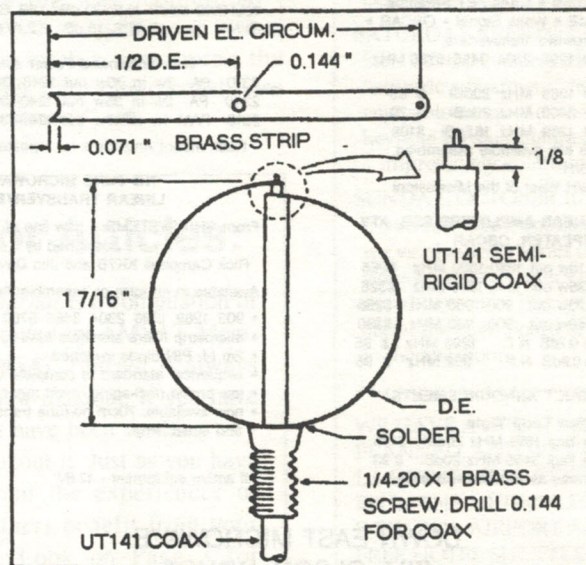
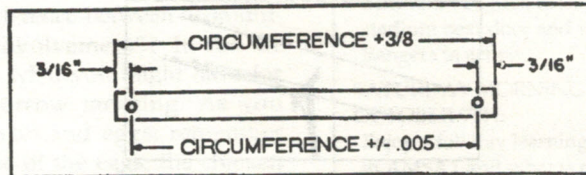
### Drilling the boom

Mark the element locations on the boom; it seems that millimeters are easier to use than inches (It's hard to find a tape measure that reads out in decimal inches!), so I converted W1JR's dimensions to metrics. Lay a tape along the boom and mark each location. Center punch each mark. Dimensions are listed from the back end of the boom to prevent cumulative errors.

Drilling the boom squarely can be challenging. Eyeballing doesn't work. I have had good results using a hardware store "universal drill guide" with a V-notch designed to drill holes in the center of a pipe. Before you start drilling, it is best to devise a method of registering (preventing boom rotation) the boom while drilling, thereby keeping all the drilled holes in line. You must also support the boom high enough off the bench so that the drill guide can slide along under the boom. One way to do this is to lay the boom on a long bench. Then drill a hole



13cm Antenna Support Assembly.



Driven Element Construction.



through the boom large enough to clear a 1 1/2" long No. 4 or 6 wood screw. Run the screw through the hole in the boom and into the bench only about 1/4". The boom will now be free to move up and down as the drill guide is moved, but will be rotationally fixed. Two screws in different locations may be required if your drill guide has a large base and you can't get all the holes without hitting the screw. Slide the drill guide along the bench with the boom in the V-notch and drill each 0.116" hole. Drill the driven element hole 1/4" in diameter to clear its brass mounting bolt.

### Assembly

When assembling the elements to the boom, use 4-40 x 3/4" stainless screws, nuts and lockwashers. Put the lockwasher between the nut and the boom, not under the element. Coat the ends of each element with a corrosion inhibitor such as "No-Al-Ox" before assembly. Weather turns aluminum into aluminum oxide, which is a dandy insulator. No-Al-Ox is available from your local electrical supply house and well worth the nominal cost. I use it on all my antennas. Assemble the

elements with the overlaps all facing the same direction.

### Driven Element

To make the driven element, drill a 0.144" (#27 drill) hole lengthwise through a 1/4 x 1" brass flat head bolt. Mark the center of the driven element and drill a 0.144" hole there. You must assemble all the driven element parts (element, bolt, nut, boom, etc.) on the UT-141 hardline before you solder things together. Use hobby (low-temperature) silver solder and flux for all outdoor connections as it does not deteriorate from weather like regular rosin core solder. Finally, solder the hardline to the brass bolt head. If you have a method of measuring SWR (or return loss), leave the point where the UT-141 passes through the bolt head unsoldered. SWR can be adjusted by stretching or compressing the driven element here. A note: Go easy on the heat on the hardline. If you overheat it, it can swell and rupture. Then you will become very aggravated and will start over. I did.

### Support Bracket

The 8' long, 1/2" diameter boom is flimsy and requires mounting support.

The strap mounting method shown is easy and works. A single U-bolt through the support boom mounts the whole thing to the antenna cross boom.

### Mounting

A note on antenna mounting: Many satellite operators use a nonmetallic cross boom between their antennas. This tends to cut down intermod problems on the harmonically related modes, such as Mode J. If you mount this (or any) antenna on an insulated boom and leave the preamp connected, remember the path that atmospheric static electricity has to take to go down the lead-in coax into the shack. Yes, right through the preamp. This is a double problem. One of the nice things about the loop yagi is that, since it is all metal, simply grounding the mounting bracket will insure that atmospheric static is channelled harmlessly to ground rather than through your nice, expensive GaAsFET preamp. In any event, keep the coax disconnected from the equipment and grounded in the shack when the antenna is not in use, and never use the antenna when thunderstorms are in the area. I strap-ground my 1296 and 2401 antennas right up on the mounting boom and have not lost a preamp to static yet.

### Tune Up

If you have UHF test equipment, you can now optimize the antenna by maximizing return loss at the frequency of interest. Do this by compressing or stretching the driven element. Also, some change in SWR can be effected by bending the reflectors and first director toward or away from the driven element. If, however, you don't happen to have such toys laying around, the antenna will usually work pretty well without adjustment. Mount your preamp at the antenna feed-point, point it at a satellite (DOVE is a good start since it's quite strong) and see what happens.

### Performance

The single loop yagi described here has proven satisfactory for all current satellite Mode S reception. Since the Microsats are low and powerful, signals from them are strong. AO-13, on the other hand, is rather weak. A single loop yagi is fine for CW but sometimes provides rather less than armchair copy on SSB. This antenna's real beauty is the fact that it is very small and can be nestled in amongst what ever else you have up on your antenna tower.

This antenna is stackable; in a future issue I will provide designs for 2 and 4 way power dividers that allow twin and quad arrangements. ■

## DOWN EAST MICROWAVE



### MICROWAVE ANTENNAS AND EQUIPMENT

- Loop Yagis • Power Dividers •
- Complete Arrays • GaAs FET Preamps
- TROPO • EME • Weak Signal • OSCAR •
- Microwave Transverters

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2445 LYK 45el 1269 MHz 20dBi \$ 95

1245 LYK 45el 2400 MHz 20dBi \$ 79

2455 LYK 55el 1269 MHz 18.5dBi \$108

Above antennas kits available assembled.

Add \$ 8 UPS S/H

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2335 PA 10 in 35w out 1240-1300 MHz \$325

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3335 PA 10 in 40w out 900- 930 MHz \$330

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### NEW PRODUCT ANNOUNCEMENTS

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## Apogee View:

(continued from page 3)

recent years, in addition to its Mode J use, the portion of the band from 144.30 to 144.50 has been used more and more for various kinds of FM simplex activity, including some packet, as well as a few local FM voice nets of various kinds. Since satellite operations is sanctioned by the ARRL Band Plan, North American amateurs feel no compunction in transmitting in the 144.425 to 144.475 range to access Mode J. But in Europe, where band plans are regarded with considerable reverence, few will do so.

In the case of Phase 3D, the band chosen for the 2 meter receiver is 145.800 - 145.975, so no one should have any problems using it.

The biggest problem with this part of 2 meters is that it is becoming increasingly crowded with satellite activity. Virtually all of the digital birds have uplinks in the 145.8 to 146.0 region. This poses a real threat to 2 meters being viable as either an uplink or a downlink. When Phase 3D is in Mode J (probably to be called V/U), will it be completely clobbered by stations accessing the various Pacsats? On the other hand, what is the potential for QRM from local pacsat uplinks when one is trying to copy a 2 meter downlink from Phase 3D? In rural areas, this type of QRM will probably not pose a problem; but in large urban communities, it could be quite serious. Furthermore, what is the potential for direct interference to the pacsats from a Phase 3D 2 meter downlink?

It is these kinds of potential problems that lead many to believe that Phase 3D's real future lies in the higher bands.

Nevertheless, a substantial number of users, many of whom are financial contributors to the Phase 3D fund, have been very firm in expressing their desire to have Mode B included. They were heard, and the Phase 3D Design Team DID incorporate provisions in the satellite's design for a 2 meter transmitter. The most visible of these provisions is the three dipole 2 meter array which can be seen on the antenna side of the spacecraft. Those provisions still exist. They have NOT been deleted.

Nonetheless, if we are going to have Mode B, or Mode V/U, or whatever its going to be called; we must have a 2 meter transmitter which is capable of meeting the rather stringent requirements imposed by the launch authorities, as well as the space environment that Phase 3D will experience. Many of those working actively on the Project, have been beating the bushes, and have turned up a few good

prospects. Unfortunately, a few, that were thought to be promising have been eliminated, or taken themselves out of the running. But, there remain a few that are studying the requirements.

Speaking of the "requirements", one of the things which we knew was needed was a clearly stated specification for a 2 meter transmitter. Having had a hand in writing a few specifications during my employed years, I began working on one. Of course, I didn't have some of the details, but I did know most of the general needs, as well as many of the parameters for which requirements had to be determined. Many of these were readily supplied by Dick Jansson and Karl Meinzer. The result is a specification that can be handed to prospective suppliers. The document may also serve as a model for other Phase 3D modules as well.

If you, or someone you know is an RF designer, who might be willing to commit to taking on a challenging task, one which may benefit Amateur Radio for years to come; PLEASE get in touch with me right away. I will see to it that you receive a copy of the specification immediately. But, time is rapidly running out. If we can't find someone to develop a 2 meter transmitter, there won't be Mode B on Phase 3D, no matter how much we might want it. It's as simple as that.

Notice that I used the term "commit". What is the difference between "commitment" and "involvement"? It can be summed up in what you might have for breakfast tomorrow morning. As you enjoy your bacon and eggs; remember that, in the case of the eggs, the chicken was "involved"; but to put the bacon on your plate, the pig was "committed". Obviously, what I am getting at is that taking on a job, such as developing the Phase 3D 2 meter transmitter, constitutes a serious "commitment". ■

## Call for Articles:

*The Amsat Journal* is a compilation of material submitted by AMSAT Members. *The AMSAT Journal* is always looking for new material. If you have a project you have been working on - let us know about it. Just as you have benefited from the experiences of others, let others benefit from your experiences. Look on Page 3 for details describing how to submit material to the Editorial Office. ■

## W5IU Provides Advance Agenda Of AMSAT-NA's Space Symposium Information

### ELEVENTH ANNUAL AMSAT SPACE SYMPOSIUM

OCTOBER 7-10, 1993

LA QUINTA INN  
ARLINGTON, TEXAS

State Hwy 360 and Interstate-30  
Hosted by the North Texas AMSAT Members

THURSDAY MORNING, OCTOBER 7TH:  
Meet at La Quinta Inn at 9:00 a.m. and visit various electronic surplus stores in the Fort Worth/Dallas area. Transportation and expert guide will be provided.

FRIDAY MORNING, OCTOBER 8TH:  
Registration begins at the La Quinta Inn. An antenna test range will be set up near the hotel, so bring your new antenna design and test it out.

FRIDAY AFTERNOON, OCTOBER 8TH:  
Presentation of the first of many outstanding technical papers begins. Papers will be presented in the spacious La Quinta Conference Center.

FRIDAY EVENING, OCTOBER 8TH:  
Rendezvous with your AMSAT friends and families at the La Quinta Inn and make dinner plans. This will be an excellent opportunity to sample the local Texas BBQ and Tex-Mex cuisine. Or just go to the stadium next door and watch the Texas Rangers in action.

SATURDAY MORNING & AFTERNOON, OCTOBER 9TH:

Enjoy a full day learning about what's new in AMSAT and what is planned for tomorrow. Topics include Phase 3D, Pacsats, DSP modems, and much, much more.

SATURDAY EVENING, OCTOBER 9TH:  
Start out the evening with the traditional "attitude adjustment" hour followed by an enjoyable banquet dinner. As usual, the keynote speaker planned for this year will impressively entertain you.

SUNDAY, OCTOBER 10TH:

If you can spend another day with us, we've planned a series of technical sessions on various topics including the traditional Beginners Forum. And don't forget about the open Board of Directors meeting in the afternoon.

+++++  
WE HAVE A GREAT WEEKEND PLANNED, AND WE'VE RESERVED THE LA QUINTA INN, CENTRALLY LOCATED IN THE METROPLEX AREA. FLY INTO DFW AIRPORT AND TAKE THE FREE HOTEL SHUTTLE TO THE LA QUINTA INN, ARLINGTON. CALL AMSAT AT 301-589-6062 FOR REGISTRATION DETAILS.



## Ground Tracking:

(continued from page 1)

the system can display and track any station with a GPS or LORAN-C navigation device interfaced to a packet TNC. Currently a GPS receiver, TNC and radio can be assembled into a package about the size of a cigar box and costing under \$800. This cost will probably be under \$400 by 1994. This Automatic Packet Reporting Software or APRS is perfect for the application of packet radio to real time events. The following article addresses the application of APRS to future AMSAT space packet experiments.

### Background

As a demonstration to students of the viability of amateur packet radio in space communications, we routinely keep a TNC and terminal display on the space frequency of 145.55 MHz. Each time the space station MIR comes over, the screen is filled with packet headers showing the number of stations attempting connections. To HAMs there is a wealth of information on the screen. Due to the FCC assigned callsign areas, each call is representative of a geographical location and you can see the progress of the spacecraft across the country. Unfortunately, whenever I excitedly point this out to the students, it is soon apparent that all they see is gyberish on the screen, because they do not have the background understanding of callsign recognition.

### Using APRS for Satellite Station Plotting

To make the monitoring of MIR and Shuttle packet more rewarding, I have for years been thinking of writing some map software that could instantly plot the location of packet stations. The software simply scans packets looking for a properly formatted position report consisting of the station's latitude and longitude. This report is placed as the first 19 characters of a station's BText which can also contain any other text or comments to the end of the line. These characters can resolve any location on the globe down to the nearest 60 feet!

In my opinion, most of the joy of DXing either by HF, VHF or satellite is the fascination of making contact with a station in some far away place. Usually the first information exchanged on any such DX contact is the station location. Why not include that location information automatically via packet? In the space application, we already have three digipeaters in space, MIR, SAREX, and occasionally AO-21. Further, there are a number of

amateur satellites currently under construction which will also carry AX.25 1200 baud digipeaters.

The past experience on both MIR and SAREX is that only a small handful of stations are successful out of the thousands of stations trying. This leads to frustration and actually very little successful communication. If instead of attempting connections, stations simply transmitted their BText to the orbiting spacecraft there would be a more equal competition. This would spread out stations to no more than one transmission every 10 seconds as a minimum. Secondly, only one packet needs to be received without error on the spacecraft for the uplink to be considered a success. Finally, not only is the successful station rewarded with seeing his packet digipeated, but all thousands of stations in the same footprint are rewarded by seeing the geographic location of each successful station.

This pattern of successful stations plotted on the map in real time has a number of revealing attributes. First it shows the number of successful stations. Second it shows relative station merit by how far from the satellite ground track a station appears. Stronger stations should be successful further from the satellite than less capable stations. The spacecraft antenna pattern should also be apparent by the geographic distribution of contacts. Finally, since each packet position report contains a comment field, a rudimentary

Satellite broadcast capability is effected. Stations with real-time QST announcements can be seen by thousands of radio amateurs in an instant.

### Balloon Payload Tracking

Another near-space application is the tracking of balloon payloads. Not only can everyone plot the position of the payload, but also if the TNC is used as a digipeater, all tracking stations can see each other. If chase vehicles are also transmitting GPS positions then they can be directed to the exact splash point even if they have no computer display. Any monitoring station observing the plotting of both the balloon and the chase vehicle just gives voice directions to merge the two stations.

### Summary

The Automatic Packet Reporting System is a new direction for packet radio. It takes advantage of packet radio data delivery to send meaningful positional information which can often take the place of hundreds of message characters to communicate the same information. It also supports short text broadcasts and directed messages between operators. Finally with the increasing popularity of GPS devices, it fills the need for a software package for tracking GPS reporting stations. For a copy of the software, send formatted disk and postage paid envelope to Bob Bruninga, WB4APR, 115 Old Farm Ct., Glen Burnie, MD 21060. ■

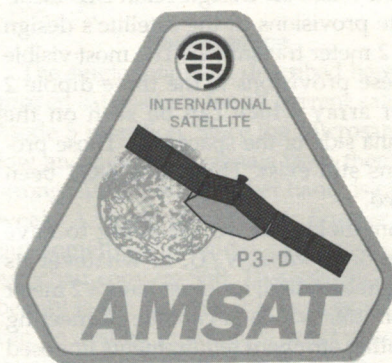


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# The New Shape of P3-D

## A Development Status Report

By: Dr. Karl Meinzer, DJ4ZC

[Reprinted from the AMSAT-DL Journal, Nr.1/20 March/May 93 issue, Translated by Don Moe, DJ0HC/KE6MN]

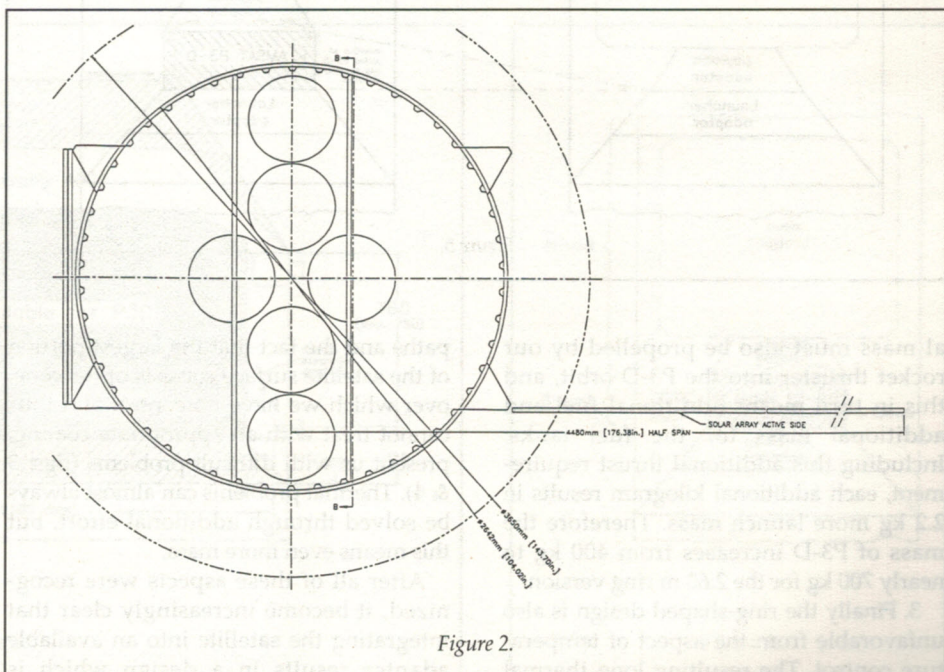
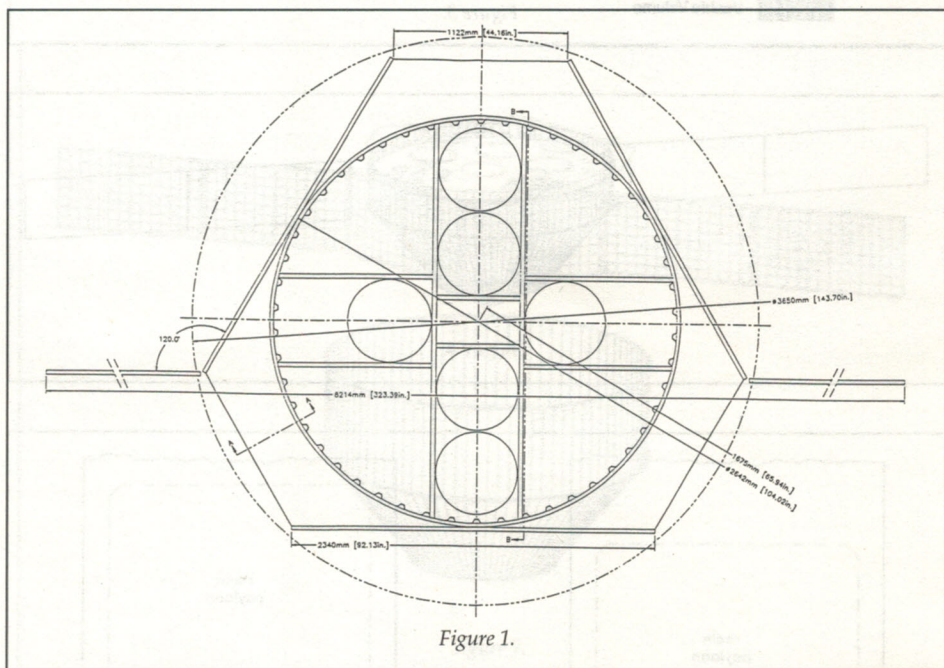
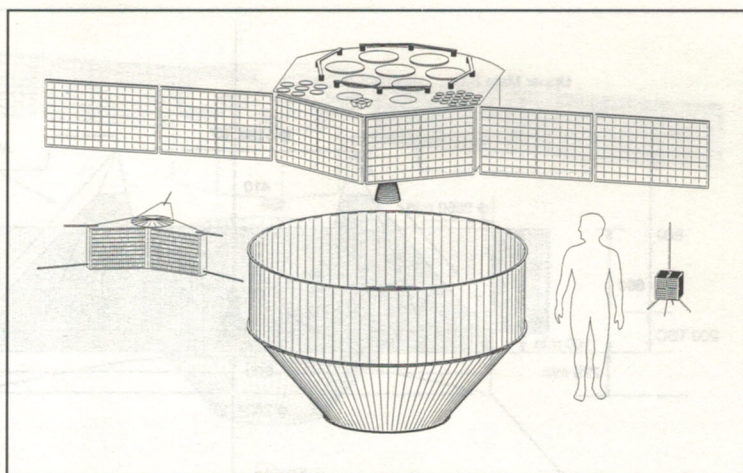
At the end of 1992, ESA withdrew the 1920 mm interface from the "User Handbook" for Ariane 5. This was a circular junction surface which would have joined our P3-D satellite to the rocket. Our entire P3-D design had centered around this junction and the supporting structure of P3-D was a conical adapter that fit this 1920 mm interface.

The ESA was naturally aware what this decision would mean to AMSAT and therefore suggested six alternative designs for P3-D so that it could be launched with flight AR-502. All of these suggestions were based on the assumption that P3-D would be built around another adapter, resulting in a structure that could simultaneously carry other satellites above P3-D. We have carefully analyzed the ESA suggestions and come to the following conclusions:

1. In the case of the old 1920 mm interface, the measurements of the supporting cone just happened to fit very well with the requirements of our intended satellite. The average cone diameter of nearly 1.5 meters represented a nearly ideal supporting structure in which optimal volumes would be available inside the cone for the propulsion system and outside for the electronics.

In the alternative ESA suggestions, the segmentation of the satellite would occur at much more unfavorable locations. This would mean that additional supporting structures would be necessary for mounting the subsystems of the satellite. In fact the resulting designs are so detrimental that nearly all ESA suggestions proved to be inappropriate. Only a single design would yield a satellite that would fulfill the mission goals for P3-D: a cylinder of 2.63 meters in diameter around which P3-D could be built.

2. If P3-D would not have to carry another satellite, it would weigh nearly 400 kg. For us this number is basis for all mass computations. If P3-D now has to be integrated in and around a 2.63 m cylinder, the weight naturally increases. We have investigated two different possibilities of joining the P3-D satellite to this cylinder (figs 1 & 2). Both immediately result in a mass increase of 150 kg, and that's unfortunately not all. This addition-





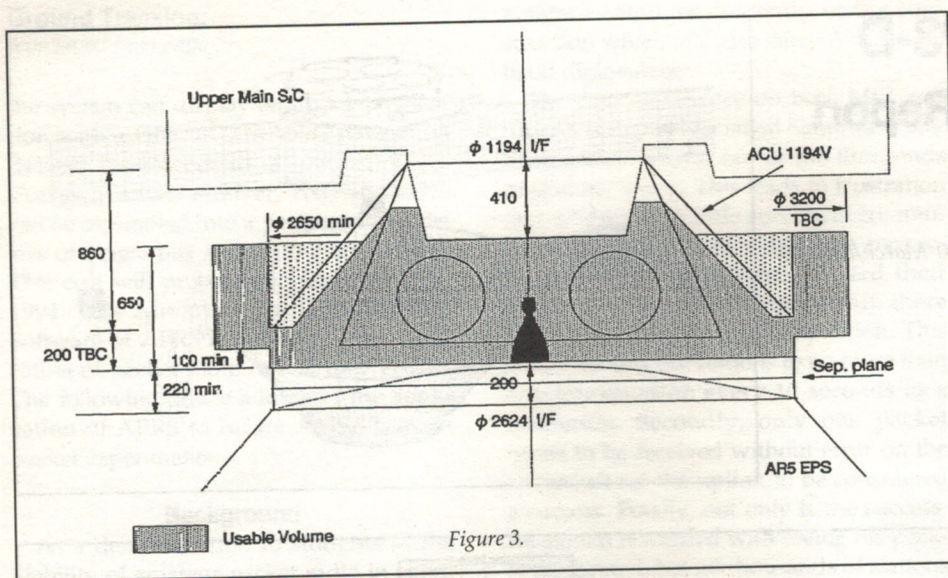


Figure 3.

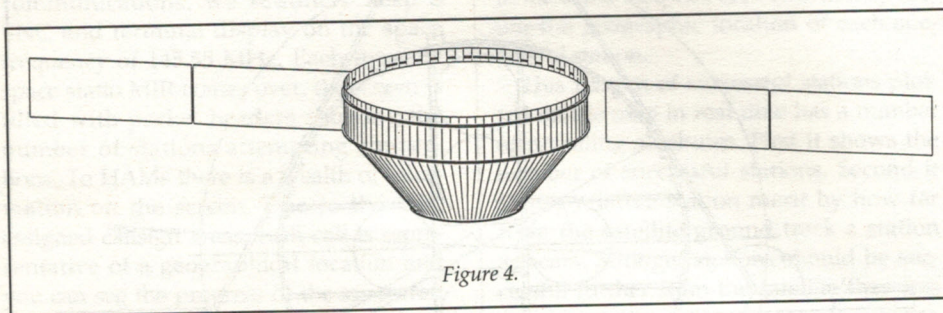


Figure 4.

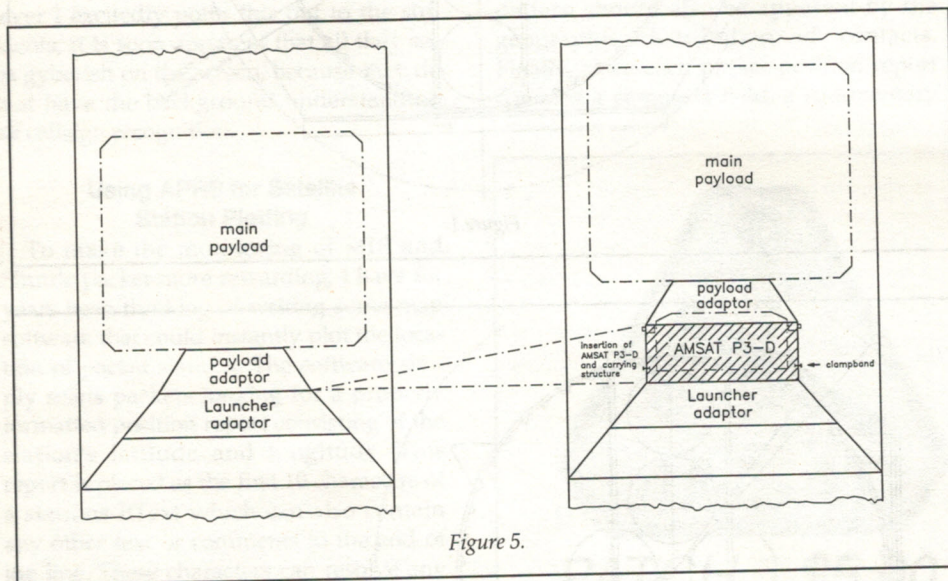


Figure 5.

al mass must also be propelled by our rocket thruster into the P3-D orbit, and this in turn means additional fuel and additional mass for the fuel tanks. Including this additional thrust requirement, each additional kilogram results in 2.2 kg more launch mass. Therefore the mass of P3-D increases from 400 kg to nearly 700 kg for the 2.63 m ring version.

3. Finally the ring-shaped design is also unfavorable from the aspect of temperature control. The resulting long thermal

paths and the fact that the largest portion of the satellite surface consists of the cone, over which we have no control and thus cannot treat with an appropriate coating, present us with difficult problems (figs. 3 & 4). Thermal problems can almost always be solved through additional effort, but this means even more mass.

After all of these aspects were recognized, it became increasingly clear that integrating the satellite into an available adaptor results in a design which is

indeed very far removed from an optimal usage of mass and thus would scarcely serve as a model for additional future satellites. The possible future use of our designs is one of the motivations for ESA to grant us favorable terms for a launch. We have thus reverted to the old idea of isolating the satellite from the carrying structure of the other payloads and initiating a separation after launch. On January 27, 1993 a meeting with ESA took place in Paris in order to pursue such prospects and if possible arrive at a decision for the new P3-D configuration.

During the meeting it became evident that ESA was also seriously interested in a weight reduction since only 530 kg could be allocated for the entire P3-D package. The new approach was based on designs (figs 5, 6 & 7) in which a 2.63 m cylinder is inserted between the adaptor of the main payload and the rocket. AMSAT P3-D will thus be attached at three locations within this cylinder and launched as separate satellite. Following the launch, the three attachments will be separated using explosive bolts or nuts, and P3-D will be ejected from the cylinder by three springs. This arrangement is therefore very similar to the launch configuration of OSCAR-13. So that P3-D can fly out of the cylinder, it must be open on the lower side, meaning that the cylinder must itself previously be separated from the rocket. The cylinder will thus consist of two parts: a 250 mm section of the cylinder will sit atop the rocket and be joined to the upper section (750 mm) by a circular clamp band. After the launch this clamp band will loosen to allow the upper cylinder section along with P3-D to fly away from the rocket. At a later time P3-D can leave the cylinder without hindrance. For this configuration AMSAT will provide in addition to P3-D only the upper cylinder section. The lower section and the clamp band will be supplied by ESA. Additionally AMSAT must naturally provide the three explosive bolts and the associated electronics.

Further aspects of this configuration were discussed during the meeting with ESA. For example, only very simple interfaces will be needed for the various cables and for the assembly of the entire structure. This will significantly facilitate the work prior to launch.

In particular the assembly of the payloads in Kourou can progress concurrently to a large extent: (Fig. 9)

The upper satellite will be mounted together with the associated cone as one unit. (Section A).

The AMSAT cylinder with the clamp



band and the P3-D satellite will be assembled as a unit. (Section B).

Subsequently our B unit can be mounted on the rocket or on a SPELTRA, the carrying structure for double launches.

In the final step the unit A will be placed upon our unit B and fastened in place (fig. 9). For this to work only three suspension points can be provided in unit B.

Altogether the conversation in Paris determined that the design just described is presumably the most favorable configuration that has yet been found for P3-D. Both sides thus agreed to pursue the P3-D project based on this approach.

Although this configuration means starting from scratch in several regards, the perspectives for P3-D are actually even better now. Since the satellite itself can be optimized independently of extraneous demands, its amateur radio performance will certainly not be any worse than previously planned. The separation of the supporting structure and satellite means that these units can also be manufactured separately, which significantly alleviates the work and scheduling difficulties. Finally the reduced mass also results in a satellite that is simpler to handle and transport, and probably will also result in lower launch costs. However, many problems with P3-D remain to be solved and there is no shortage of work.

The most important task for the future is to find an optimal shape for the satellite. Figures 6 and 7 show two possible configurations. In figure 7 an equilateral hexagon is assumed. This shape makes good use of the available volume, but necessitates an additional segmentation of the solar generator panels with associated

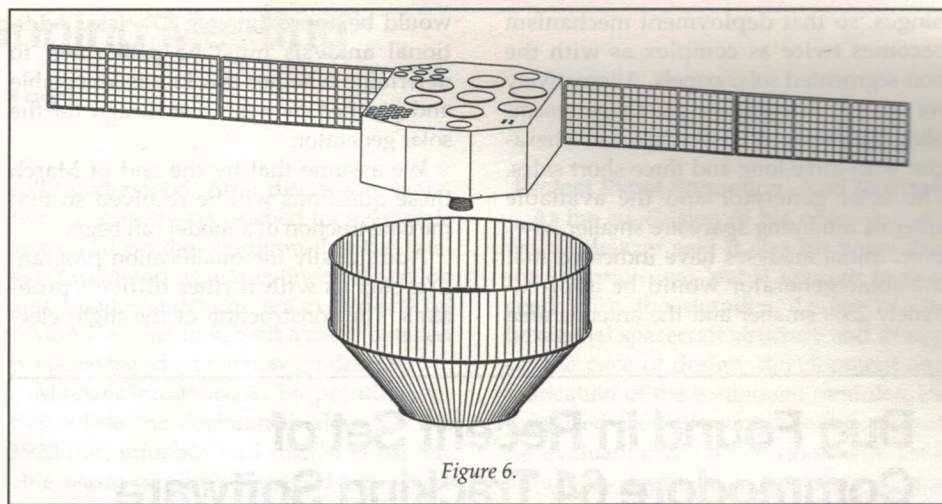


Figure 6.

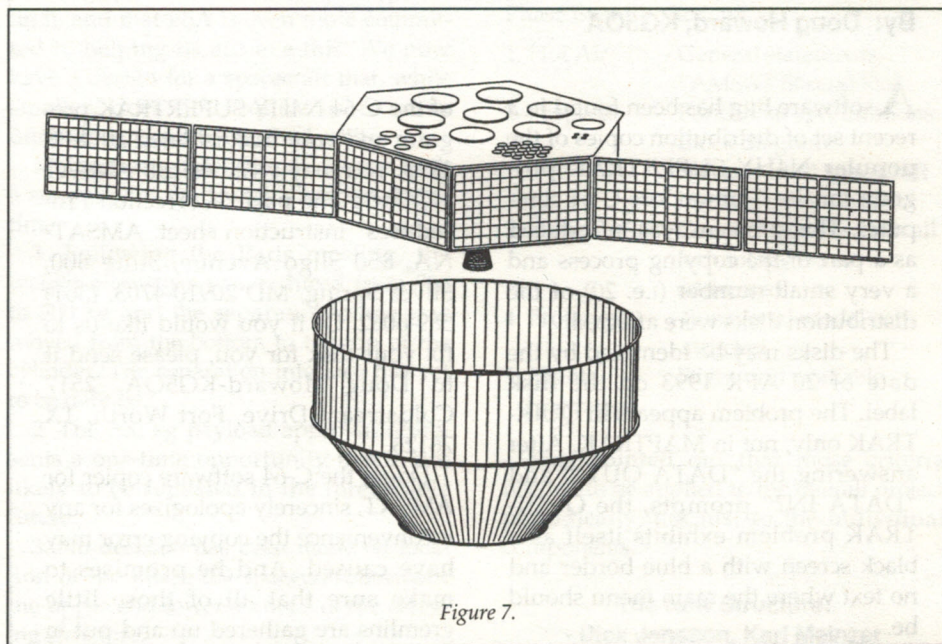


Figure 7.

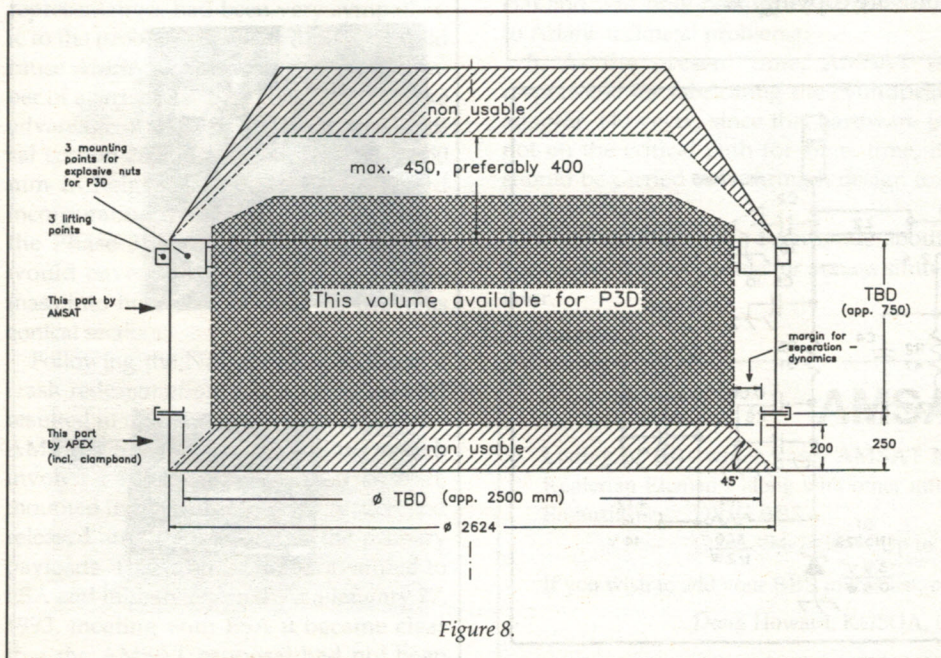


Figure 8.

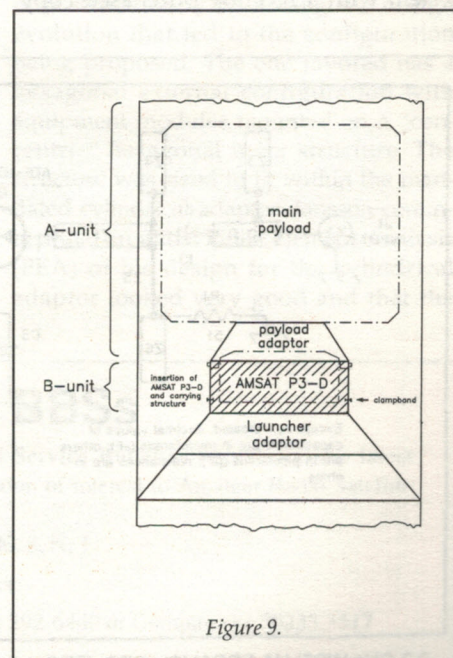


Figure 9.



hinges, so that deployment mechanism becomes twice as complex as with the non-segmented solar panels. Alternatively we are also investigating a shape resembling the previous P3-D shape, i.e. a hexagon with three long and three short sides. The solar generator and the available antenna mounting space are smaller however. Initial analyses have indicated that the solar generator would be approximately 25% smaller and the antenna area

would be approximately 30% less. Additional analysis must be performed to determine whether this loss is acceptable and justified by a simpler design for the solar generator.

We assume that by the end of March these questions will be resolved so that the construction of a model can begin.

Additionally the qualification program presents us with further difficult problems. The construction of the flight elec-

tronics will also begin this year. And finally our ongoing problem, namely shortage of funds, will continue to demand much energy and commitment from us.

Despite all this, a certain cautious optimism is appropriate. There is a justifiable hope that P3-D will actually fly in 1996. This will not only replace OSCAR-13 in time prior to its demise, but will also open an essential new dimension for amateur radio. ■

## Bug Found in Recent Set of Commodore 64 Tracking Software

By: Doug Howard, KG5OA

A software bug has been found in a recent set of distribution copies of the popular N4HY SUPERTRAK program for the Commodore C-64 computer. This problem was introduced as a part of the copying process and a very small number (i.e. 20) of the distribution disks were affected.

The disks may be identified by the date of 20 APR 1993 on the disk label. The problem appears in QUIKTRAK only, not in MAPTRAK. After answering the "DATA OUT?" and "DATA IN?" prompts, the QUIKTRAK problem exhibits itself as a black screen with a blue border and no text where the main menu should be.

If you are experiencing this problem with a recently purchased copy

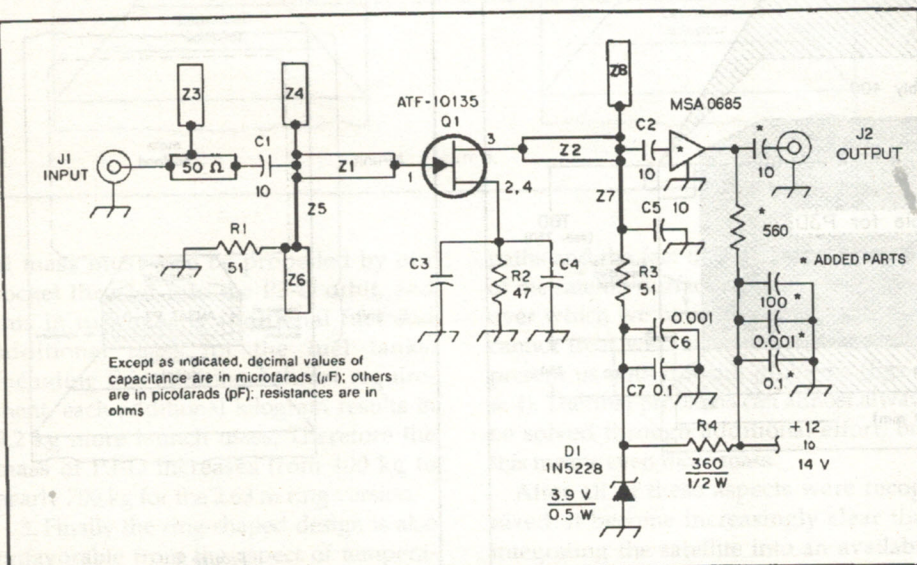
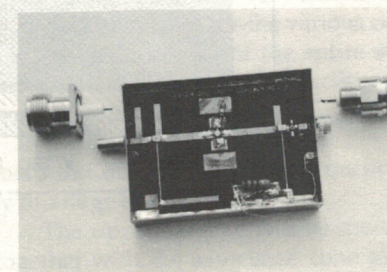
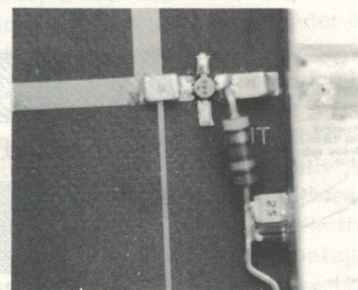
of the C-64 N4HY SUPERTRAK program and your disk is dated 20 APR 1993, you may write or call AMSAT HQ for a one page "Correction Procedures" instruction sheet. AMSAT-NA, 850 Sligo Avenue, Suite 600, Silver Spring, MD 20910-4703. (301) 589-6062. Or if you would like us to fix your disk for you, please send it to Doug Howard-KG5OA, 2517 Coldstream Drive, Fort Worth, TX 76123.

Doug, the C-64 software copier for AMSAT, sincerely apologizes for any inconvenience the copying error may have caused. And he promises to make sure that all of those little gremlins are gathered up and put in their cages before the next round of software copying. ■

## Addendum to "S Band Reception: Building the DEM Converter and Preamp Kits" March/April 1993

Ed Krome KA9LNV  
1023 Goldfinch Dr.  
Columbus IN 47203  
Compuserve 71611,76

In the last AMSAT Journal, the photos showing details for how to add a high gain second stage to the WB5LUA 13cm "no tune" preamp were inadvertently left out. Without the photos, the text description was rather obscure. Therefore, here are the missing photos showing the additions to the existing circuit board.



2.3 GHz WB5LUA PREAMPLIFIER (FROM QST, MAY 1989) SHOWING ADDITION OF MMIC SECOND STAGE. KA9LNV



# Phase 3D Project Planning Meeting

Orlando Florida, February 25-28, 1993

## MEETING RECORD

Thursday, February 25

### Opening Remarks:

The second Phase 3D Project Planning Meeting to be held in Orlando, Florida convened on Thursday morning, February 25, 1993, at the Plaza Inn, 603 Lee Road. Dick Jansson, in his capacity as host, welcomed the group, drew attention to the proposed agenda, provided administrative information and announced two evening social events to be held at his and Stan Wood's homes. He then turned the meeting over to Dick Daniels who drew attention to the draft agenda that had been previously circulated. With some changes to accommodate schedules of individuals, the agenda was approved. Karl Meinzer was the first speaker.

### Status of ESA discussions and agreements: - Karl Meinzer

Meinzer began with a review of the changes that had resulted from the November 18, 1992 meeting with representatives from the European Space Agency (ESA) at which we were given an unofficial notice of an impending decision not to support the 1920 mm separation interface for the Ariane V launcher, a key requirement for the AMSAT design for a Phase 3D spacecraft incorporating the conical adaptor that mounted one of the primary payloads. He said that the ESA representatives had been very sympathetic to the problems that this decision would cause AMSAT and had suggested a number of alternatives to be considered to take advantage of the new interface, a cylindrical section 2624 mm in diameter and 750 mm in height. Most of these involved incorporating the cylindrical section into the Phase 3D spacecraft structure and would have required carrying this extra mass into final orbit as with the previous conical section.

Following the November 18 meeting, a crash redesign effort was undertaken that resulted in the recommendation to ESA by AMSAT for an alternative approach involving a smaller separable spacecraft, mounted inside the cylindrical section and released after deployment of the primary payloads. This proposal was forwarded to ESA and initially rejected. At a January 27, 1993, meeting with ESA it became clear that the AMSAT proposal had not been

fully understood. After discussion, tentative agreement was reached for a separate spacecraft on the condition that the total system, including the cylindrical section and separation devices, not exceed 500 kg. AMSAT agreed to submit a more detailed proposal based on the new guidelines.

Meinzer summarized by pointing out that while the decision to abandon the 1920 mm interface had caused considerable waste of effort, the good news was that we still had agreement with ESA to launch a spacecraft within the 500 kg mass limit, and that ESA is even more committed to helping us achieve this. We now have a design for a spacecraft that, while smaller, does not require us to carry unneeded mass into our final orbit.

Meinzer concluded the discussion with a summary of the launch situation at this time.

1. Following the Paris meeting, the weight allowance was reduced from 530 to 500 kg and the separation plane was moved from the bottom to the top of the cylinder. The separation interface has yet to be defined.

2. The 500 kg payload approval represents a one-time opportunity that is not likely to be repeated in the foreseeable future.

3. No decision has been made on location of the Phase 3D spacecraft between the upper and lower sections of the carrying structure.

4. The launch date of April 1996 is official and will only be slipped in response to Ariane technical problems.

5. At the present time, AMSAT is responsible for fabricating the cylindrical adaptor. However, since this hardware is not on the critical path for some time, it should be carried only through design for the present.

6. No decisions have been made about requirements or schedule for a mass simulator.

### Project Event Sequence - Karl Meinzer

At the conclusion of his opening summary, Meinzer said it was his belief that the situation was stable enough to proceed with the detailed design of the hexagonal spacecraft structure and to step up the pace of design, development and fabrication of the equipment modules. He proposed the following Event Sequence for evaluating where we stood with individual developments in the following discussions.

| Phase Event        | Actions                                                                                           |
|--------------------|---------------------------------------------------------------------------------------------------|
| 1. Hot Air         | - General statements, "AMSAT Should Do"                                                           |
| 2. Proposal        | - Functional specifications<br>- Block diagram<br>- Soft and hard spacecraft interfaces described |
| 3. Design          | - Circuit diagrams with all technology items addressed                                            |
| 4. Prototype       | - Functional model constructed                                                                    |
| 5. Flight Hardware | - Flight unit available                                                                           |

Karl pointed out that these criteria needed to be applied to the overall project periodically, not just to the individual components.

### The New Structure: - Dick Jansson, Karl Meinzer

Dick Jansson led in the discussion of the new structure by reviewing the design evolution that led to the configuration being proposed. The one favored has a hexagonal external configuration with equipment modules mounted on a "concentric" hexagonal inner structure. The structure was sized to fit within the mandated cylindrical adaptor. Jansson continued that an initial Finite Element Analysis (FEA) of his design for the cylindrical adaptor looked very good and that the

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fabrication should be very straightforward using sheet aluminum and stringers.

In the discussion that followed, it was agreed that the hexagonal structure had merit but that Jansson's proposal for an overhanging top plate to improve the antenna ground plane would make it too difficult to access panel release mechanisms and should not be pursued. There was agreement that the hexagonal configuration without overhang should be baseline.

**DECISION:** The hexagonal configured structure is adopted as the baseline for the redirected project.

#### **Solar arrays:**

##### **- Dick Daniels, Dick Jansson**

Dick Daniels reported that in their most recent discussion, Jan King had committed to helping with the procurement of the solar arrays if they are to be procured in the U.S. His work responsibilities with Orbital Science Corporation (OSC) are keeping him in touch with likely suppliers, including Applied Solar. He confirmed that Joe Capitano, while no longer with Applied Solar, is now in business for himself as a broker and could still be of assistance. Asked about status of the task to have tests conducted on the effects of high power RF fields on gallium arsenide cells, Daniels responded that while an individual had been identified who has the facilities to conduct the tests, final arrangements had not been made to get the cells to him. Tom Clark suggested that it would be a good idea to include testing of possible GPS antennas for RF sensitivity at the same time.

**ACTION:** Daniels to follow up with the individuals involved to complete the solar cell RF testing and to investigate having GPS antenna tests included.

Dick Jansson next reported on his discussions with Tod Torrico, owner of a composites firm, to obtain graphite composite solar array panels. It still appears possible that we can obtain the panels at little or no cost. Questions were raised about the RF characteristics, weight and strength of graphite composite panels.

**ACTION:** Jansson to contact Torrico to obtain the requested information.

#### **Battery Charge Regulator:**

##### **- Karl Meinzer**

Meinzer reported on his visit to Bandi Gschwindt in Budapest last October and confirmed that Bandi has agreed to produce the BCRs for Phase 3D. The configuration agreed to has three independent low power units, each without redundancy, designed to interface with 28 v batteries. The BCR's will also be the source of redundant 10 v regulated sources. Karl said that while Bandi is faced with political and economic problems and staffing attrition, he still has his key people and is confident of being able to deliver.

#### **Batteries: - Dick Jansson, Karl Meinzer**

Jansson reported that Weber State currently had in hand two donated battery packs. One was a 13 v nickel hydrogen package, the other a Nickel Cadmium unit. Neither battery appeared desirable for flight, and, contrary to what Weber had been led to believe, there was no assurance that sufficient flight quality nickel hydrogen cells would be made available. Jansson said that he had conversations with people at General Electric concerning Eagle Pitcher cells, but had not been able to follow up. It was agreed that locating a source for the flight batteries was a high priority task and that an individual is needed to take on this task. Tom

Clark suggested discussing possible Japanese sources with Miki Nakayama when he arrived the next day.

**ACTIONS:** Bill Tynan took action to follow up on Jansson's efforts to locate possible sources and to locate an individual to focus on battery problems.

Meinzer mentioned an offer he had received from Martin Sweeting to help with testing Ni-H<sub>2</sub> batteries. It was suggested that Surrey's expertise might also be helpful if we were forced to go to with commercial NiCads.

**ACTION:** Karl Meinzer to follow up with Sweeting regarding the testing of NiCad cells and batteries.

#### **Attitude Control: - Karl Meinzer**

Meinzer next outlined the basic approach being taken in designing the attitude control system and characterizing the status as somewhere between the "Hot Air" and "Proposal" phase of development.

During the spinning phase of the mission, attitude control will be essentially the same as with the earlier Phase 3 spacecraft, relying on magnetic torquing and nutation dampers. For the new spacecraft, the "torquing rod" system is being designed in a ring configuration with four windings on the each ring - although there is a possibility that only two windings will be required. Karl said that it is necessary to know the moment of inertia of the spacecraft to finalize the design and that requirements will be much reduced with the smaller radius of the new structure.

For three-axis stabilization in final orbit three magnetically suspended momentum wheels are planned to be used. Karl, with support from Stefan Eckart, has done initial analysis that indicates feasibility of

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this approach but raises some questions about the approach. Karl plans to get in touch with an individual at ESTEC that has done work on magnetically suspended momentum wheels. In addition information is available on early work done at NASA-GSFC in the 70's and Karl believes that this may be the basis for later papers.

Regarding attitude reference, Karl's assumption is that for communications, the need is to control the spacecraft's pointing only to about 1.5 degrees precision and that drift of the wheels is sufficiently slow to give good attitude reference depending on that information except possibly during eclipse periods. This significantly reduces the need for frequent independent attitude updates and means we can probably get along without gyros. He felt that the same quality of sensors as those used in the earlier Phase 3 spacecraft can do the job taking into account the need to modify them for operation in a non-spinning environment. Karl said that he had been approached by Tom Davis, a former Weber State student that had worked on the Microsats, with the offer to build sensors. Karl said that he had given him the specifications for the earth sensor used in OSCAR 13 and asked Davis to recommend an approach for the new sun sensor. He has not heard from him recently.

**ACTION:** Ralph Butler and Dick Jansson to work with Weber to locate Davis and encourage him in the development.

Dick Jansson said that he is willing to do some initial work on availability of fiber optic laser gyros, but needs help with any follow up activity.

Tom Clark suggested that with the size of this spacecraft and the deployable solar panels, flexing of the structure needs to be taken into account. Karl assured him that he and Stephan had taken this into consideration in their analyses.

#### **The GPS approach to attitude determination: - Tom Clark**

Clark brought the group up to date on his investigations of using the GPS navigation system for both attitude and position determination of the Phase 3D spacecraft. He reported his findings on available GPS commercial receivers and receiver boards that appear compatible with what we need for Phase 3D. He said that it appears not difficult to adapt currently available hardware to the multi-antenna approach that he proposes for Phase 3D. For spacecraft location (ephemeris) determination, little modification would be required. Obtaining pointing

information, however, would require considerably more effort since the proposal is to use interferometric techniques to derive precise pointing information. Tom strongly recommended having a GPS receiver for ephemeris information. He saw, as an issue to be resolved, whether the need for precise pointing using GPS is sufficient to justify the considerable effort needed to develop this capability.

Meinzer asked whether distances to the different GPS satellites in orbit are significantly different than to stations on the ground. Clark said that he plans to investigate this next. Regarding the need for the

pointing capability, Meinzer said that very precise pointing is needed during the initial orbit adjustments, but that it is less important once in final orbit. He expressed the view that the GPS pointing capability should be considered as an operational requirement only if it could provide better information by a factor of two than other sensors.

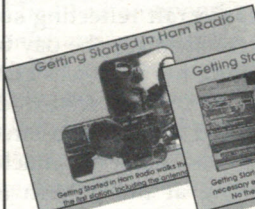
#### **Sensor Electronics Unit: - Karl Meinzer**

Meinzer said that the SEU designer and builder had not been identified, but that this is not an immediate requirement

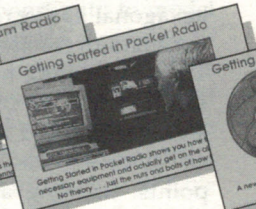


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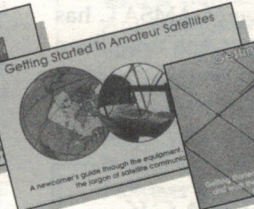
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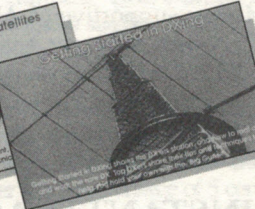
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pending better definition of the attitude control system. He anticipated a derivation of the previous SEU's.

**ACTION:** Meinzer to develop specifications for the SEU and attempt to locate an individual to undertake detailed design and fabrication.

#### **Propulsion Systems: - Dick Jansson, Dick Daniels, Karl Meinzer**

Meinzer reported that prospects still look good for the Russians providing the propellant tanks, although they owe him some "software" items which have not been received yet. He said that Leo Labutin is holding funds in escrow until things are firmed up. Jansson added that tanks are available in the U.S. but that the costs would be considerably higher.

Meinzer also reported that changes have taken place at what had been the MBB facility at Lampoldshausen. Herr Munding, the previous head of the facility, and very supportive of AMSAT, has retired. A new manager has now been appointed but the relationship at that level needs to be reestablished. Wolfgang

### **INSTANTTRACK UTILITIES**

A disk of utility programs. IT users will find some very useful. Pacsat users will appreciate the two KISS related files. The single disk contains the following:

ITPASS - Outputs a table of upcoming passes with AOS, LOS and maximum EL.

ITSORT - Rearranges IT's satellite database using your own text editor.

ITSTAMP - Adds AZ/EL/RANGE to a timestamped ASCII log file.

DISPANG - Displays OrbitDRV antenna angles in upper right corner of screen.

DUMMYKCT.ZIP - Assembly language source for the dummy RotorDRV.

DRVSVC.DOC - Specification for the Kansas City Tracker software interface.

KCTHW.TXT - Reverse-engineered hardware data on the Kansas City Tracker.

KISS2ASC - Converts a KISS binary log file to readable ASCII.

KISSFILT - Selectively filters a KISS log file by callsigns, etc.

Members & non-members \$15.

Mueller, who has supported us at the working level, is still at the facility and working behind the scenes to locate hardware sources and act as liaison if required. In particular, Mueller is looking into the availability of a titanium tank that could be used for high pressure helium.

Good progress was reported on the arc-jet thruster being developed by the University of Stuttgart group. Meinzer said that it is expected that the group will provide the total system except for the propellant tank which has been included in the items requested from the Russians. The AMSAT-DL group at Marburg is updating the power conditioning electronics package in response to experience gained during the early tests of the system.

#### **Friday, February 26, 1993**

At the beginning of the Friday session, Jansson distributed new drawings of the hexagonal spacecraft reflecting suggestions and decisions made the day before. The overhanging top plate was eliminated, the number of 2 M folded dipole antennas reduced from four to three and an allocation was made for attachment points. Looking at the pattern of the antennas, Meinzer asked what the impact would be of removing the center 435 MHz patch and replacing it with the 400N thruster. He said that the reason for considering this was that moving the antennas to the motor side of the spacecraft would relieve the very tight height constraint being imposed on the antenna designers by the current configuration. Stan Wood expressed concern that the motor bell would seriously distort the antenna pattern, but agreed to take a first look at the configuration using the Mininec antenna simulation software.

#### **Thermal Control: - Dick Jansson**

Jansson reported that his first look at the new spacecraft indicated that, while there would still be a need for a heat transport mechanism within the spacecraft in the 3-axis stabilized mode, fewer heat pipes should be needed. For the transmitters and modulators, the major heat generators, he suggested using a pumped fluid transfer approach. Meinzer questioned this complexity and suggested investigating a scenario where heat pipes are used to transmit heat from the modules to the outside of the spacecraft and then using radiation to dump the heat to space. He stressed the importance of simplification of the thermal control system even if it meant relaxing the isothermal requirements for the spacecraft.

**ACTION:** Karl Meinzer and Dick

Jansson to investigate the best ways to simplify the thermal control system including relaxation of the isothermal requirements.

#### **Spacecraft Integration/ Wiring Harness/ Etc.: - All**

After considerable discussion of the question of how and by whom the spacecraft integration should be accomplished it was agreed that no decision was possible at the time. Possible locations discussed were Weber State, Marburg and Orlando Florida, but the issues of how to assemble a team with the necessary skills for the duration of the operation remain to be resolved. It was agreed that those responsible for integration should also be responsible for the wiring harness. Another unresolved issue is where environmental testing will be accomplished.

**ACTION:** All to continue in efforts to identify a location and approach for accomplishing the spacecraft integration.

#### **The LAN System - Peter Guelzow**

Peter Guelzow provided an overview of the approach being pursued in developing the "Local Area Network" (LAN) system, planned to replace much of the complex wiring harness used in the earlier Phase 3 satellites, to distribute commands and data to and from the individual spacecraft systems and modules. The basic design, agreed to at a meeting of LAN Team in late 1992 at Marburg, was for two separate LAN systems in the spacecraft being referred to as the IHU LAN and the RUDAK LAN.

The IHU LAN is primarily a fixed interface on/off controller coupled to the Integrated Housekeeping Unit (IHU) computer to carry out basic command, control and housekeeping functions in the same manner as the IHU's of the earlier Phase 3 spacecraft. It will consist of two redundant controllers, one built from discrete CMOS logic, the other using the 68hc711g5 device. This is to give the maximum fail-safe protection should one controller fail. Data rate for the IHU LAN is expected to be in the order of 100-200 kilobits per second with 20 millisecond update interval. A standard "AART" module controller for the IHU LAN is to be centrally produced and provided to those developing the individual electronic modules. The current design for this controller uses a 69HC71165 MCO controller device. Should this not be found feasible, a controller based on discrete components would be developed.

The RUDAK LAN is being designed as the pathway for experimental and communications data and is controlled by the



RUDAK digital communications system, an expanded version of the RUDAK package currently flying on AO-21. Data rate is planned to be up to 1 megabit per second. Interfaces to this LAN will not be standard but tailored to the needs of the individual experiment packages being supported. For example, the RUDAK system will process and downlink the video output from the JAMSAT camera experiment. Tom Clark suggested that it would be useful for experimenters to have an example of a representative RUDAK interface. He also said that from the Microsat experience it was found desirable to have a PN sequence to give a one-shot command to several modules simultaneously. Meinzer agreed that this should be considered.

**ACTION:** Provision of a PN sequence for simultaneous commanding of multiple modules be investigated.

The importance was stressed of having the module controller units available to the experimenters as early as possible along with the software and interface hardware necessary for them to simulate the spacecraft IHU using a standard PC. Meinzer said that the plan is to have boards and documentation available by Mid-1993. Concerning documentation, he said that Robin Gape had offered to develop documentation of the LAN systems and that he would actively pursue this offer.

#### Antennas:

- Stan Wood, Bob Stilwell, Others

##### 10 Meter Antennas:

Wood said that Southern Africa AMSAT is looking to him to provide the 10 m antenna and that his current thinking is to have a Vee located at the rear of the spacecraft fabricated from tape measure material. He intends to model this approach on his backyard antenna range. Bill Tynan suggested contacting Ron Long at Ohio State University as a possible source of antenna modeling software.

**ACTION:** Bob Stilwell to provide Tynan with information on the Ohio State Software.

##### Two Meter Antennas:

Wood next reported on progress in developing the two meter high gain antennas. He displayed a prototype design for what he termed a triple folded dipole that could be mounted close to the spacecraft surface and provided preliminary gain and stability data from his antenna range. He also used a PC to demonstrate the gain and patterns predicted by the Mininec software package. Meinzer expressed concern with this design because of the likelihood of exces-

sive temperatures at high current points and stressed the importance of stability and ease of matching. Tom Clark suggested Kent Britain as a possible source of a network analyzer to assist with the range testing. It was suggested raising the antennas above the ground plane to increase the input impedance.

##### 70 cm Antennas:

Woods next addressed the proposed seven patch antenna system for the 70 cm high gain antennas and displayed the patterns for this configuration predicted by Mininec. Meinzer again pointed out the advantage of shifting the antennas to the motor side of the spacecraft in order to provide more clearance for the antennas to relieve the current 75 mm height constraint. This would require eliminating the center 70 cm patch antenna to accommodate the motor bell. Since the possibility had been discussed the previous day, Stan Wood had had an opportunity to model this configuration within the constraints of the Mininec software. He reported that the impact on the pattern and gain appeared to be less than he had anticipated. Given this information, the decision was made to change the baseline configuration to have the 400 N thruster mounted in the center of a six patch 70 cm antenna cluster.

**DECISION:** The baseline configuration to be modified to mount the antennas on the 400 N thruster side of the spacecraft.

##### Omni Antennas: All

There was a brief discussion of how many omni antennas would be required and on what frequencies. It was agreed that with the three-axis stabilization primary mode, having omni antennas on all frequencies is unnecessary and that the principle driver should be omni antennas on the frequencies required by the ground station operators during initial orbital operations and in recovering from any possible loss of attitude control.

**ACTION;** Meinzer to discuss with the ground station team what antennas are required for command and control purposes.

##### Higher Frequency Antennas:

- Bob Stilwell

The next presenter, Bob Stilwell, reported on progress he and Jack Colson are making with the students at the Johns Hopkins Whiting School to develop antennas for the, 1.2 GHz, 2.4 GHz and 5.6 GHz bands and to also develop two versions of a 5.6 GHz receiver.

##### L-Band Antenna:

Stilwell said that for the L-Band anten-

na, a seven patch antenna system is under development with an estimated overall gain of 15.5 dBic. An individual patch had been tested in the APL anechoic chamber and shown gain of 8.6 dBic. A power divider to feed the individual patch antennas had been designed described as a 14-way, 7:1 divider with a return loss of -22 dB on all ports. Work is currently under way to fabricate and test an assembled antenna system.

## AMSAT QSL Bureau

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1. The AMSAT QSL Bureau serves the users of all Amateur Radio Satellites with a complete QSL Bureau for all Amateur Radio satellite contacts (QSLs other than satellite QSOs will be returned).
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5. Mailings from the Bureau will be at the end of each month. All envelopes with ANY cards will be mailed at this time. The only exception is if the Amateur would like to have his/her envelope held for a certain amount of cards before being mailed. This can be done by writing just below your call sign (in the upper left hand corner) the number of cards desired in the envelope before it is mailed.
6. QSL cards that are received at the Bureau when there are no envelopes on file will be held and the Bureau will make an attempt to notify the user that he/she has cards on file. If no envelopes are sent to the Bureau within a period of 6 months, the cards will be destroyed!
7. Mailings for DX stations and individual international QSL Bureaus will go out at the end of the month.
8. Any questions about the Bureau should be sent with an SASE to the QSL Bureau Office. ■

Perry Yantis, WB8OTH  
AMSAT QSL Bureau Manager

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1850 Lisle Ave.  
Obetz, OH 43207



# 19th Annual Eastern VHF/UHF/SHF Conference

By: Lewis D. Collins, W1GXT

The 19th Annual Eastern VHF/UHF/SHF Conference will be held August 13-15, 1993 at the Quality Inn, Vernon, Connecticut. The Quality Inn is located on the Hartford Turnpike (State Rts. 30 and 83) between Exits 63 and 64 on Route I-84, nine miles east of Hartford, Connecticut.

Hartford is centrally-located at the intersection of routes I-91 and I-84, within a two-hour drive of both Boston and New York City. Most major airlines provide service via Bradley International Airport, and AMTRAK provides frequent service from Northeast Corridor locations.

The Quality Inn has both Par 3 and miniature golf on the premises. A go-kart track, theatres, playground, racquetball, and indoor pool are adjacent to the hotel. There are ample shopping malls nearby, and it is short drive to downtown Hartford.

Friday night will feature an informal social gathering. All day Saturday there will be technical talks by well-known VHFers and "rap sessions" for each of the VHF/UHF bands. A noise-figure clinic and contest will also be held on Saturday afternoon.

On Saturday evening there will be a banquet at the hotel, followed by the popular "VHF Trivia" quiz and additional informal social activities. Sunday morning there will be antenna gain

measurements (220 MHz through 2304 MHz, weather permitting) and a flea market in the parking lot.

The conference registration which includes annual membership in the Eastern VHF Society and the printed conference proceedings. The Saturday night banquet, featuring your choice of roast beef, stuffed shrimp, or chicken capon, will cost \$22.00, payable in advance.

The registration chairman is Byron Blanchard, N1EKV. Those who have attended in recent years will receive a preregistration packet in the mail. Otherwise, please contact Byron at 16 Round Hill Road, Lexington, MA 02173 for a registration form (He would appreciate a self-addressed, stamped envelope!).

Rooms are available at the Quality Inn at the special rate of \$49.95 single, \$55.00 double, including a continental breakfast. Make your reservation directly with Lori Tozier at the hotel (203) 646-5700.

The Eastern VHF/UHF/SHF Conference is sponsored by the Eastern VHF Society, the NEVHF Association, and the Northeast Weak-Signal Group. The conference chairman is Thomas Kirby, W1EJ, ably assisted by volunteers from the Northeast Weak-Signal group who have taken the lead in planning this year's conference. ■

and suggested that approaches requiring more simple feeds be considered. Tom Clark suggested that, since the hybrids were being designed as printed circuits, the patch antennas be fabricated on PC board with the hybrid printed directly on the back. Dick Jansson proposed that with the additional height provided by the decision to move the antennas to the motor side of the spacecraft, consideration be given to using small dishes or short backfire antennas for the higher band antennas. It was agreed that these options should be considered.

**ACTION:** Stilwell and Colson to investigate going to single dish or short backfire antennas for the higher band antennas to simplify fabrication and feeds.

For omni antennas, it was agreed that simple "tape measure" stubs might well be sufficient. This is to be investigated.

## Saturday, February 27, 1993

### *Introduction of new participants:*

On Saturday morning, a number of new participants joined the meeting representing organizations that had indicated an interest in participating in the Phase 3D project. These were Tim Pratt and John Musson WD8MQN from Virginia Polytechnical Institute, Derwin King W5LUU from Southwest Research Institute, and Paul Barrow VE6ATS from the University of Alberta, Canada.

### **JAMSAT Camera Experiment: - Miki Nakayama**

Nakayama brought the group up to date on progress in with the camera system being developed by the JAMSAT group. Named Spacecraft Camera experiment for Observation of Planets and Earth (SCOPE), the current design calls for three identical cameras utilizing the SONY XC-009P packages with separate CCD sensors for red, green, and blue images. These units use non-organic filtering which should assure excellent long-term color stability. The effective pixel array for each camera is 752(H) by 582 (V). The system CPU is a Toshiba MC-68301 and the memory includes a bootstrap loader of 512 kB ROM (Harris HM-6642 devices), program area of 1 Mbyte EDAC S-RAM, and data area of 2-4 Mbyte of non-EDAC S-RAM. Two cameras, narrow and wide-angle, will be earth looking. The third camera, SCOPE-C, equipped with long optics, will look out to space and be used for planetary and stellar observations. The images produced will initially be stored in data memory and then transmitted to the earth through the RUDAK downlink. The possibility of an "ATV" capability is being con-

### **S-Band Antenna:**

The S-Band antenna design is for an array of 19 short helices, each with a measured gain of 7.9 dBic for an overall gain of 15.5 dBic. Again, the individual antennas have been fabricated and tested and a 19:1 divider designed. The next step is to be fabrication of a prototype array.

### **C-Band Antenna:**

For the C-Band receiver, a short backfire array is the approach being considered. While less work has been done to date on this antenna than the others, the technology is believed to be well in hand based on similar designs used at APL.

In addition to the above efforts Stilwell said that, a cross antenna option is being investigated. Stilwell saw this design as similar to a "rampart line" antenna with which he has had experience and expressed an interest in seeing what could be done to improve the basic cross design.

Stilwell ended his report by saying that while good progress has been made up to date with the student teams, their mechanical experience is limited and an effort is being made to arrange for more support for fabrication of flight hardware from the Mechanical Engineering School. Meinzer pointed out that less complex designs would mean easier fabrication



sidered, but this would require a fourth camera.

The project status at this time is that one camera with a single CCD array is up and running and it is expected that a camera with a triple CCD array will be functional in March. A manufacturer for the SCOPE-C Cassegrain telescope has been identified but FEA assistance is needed in finalizing the design for this camera system.

In the discussion that followed the SCOPE presentation, Meinzer suggested that the configuration of the CCD array be investigated to determine if there are any blind spots on the chip. Also, Nakayama was requested to provide stability and pointing requirements of the camera system as inputs to the design of the attitude control system.

**ACTION:** Nakayama to provide pointing and stability requirements for the JAMSAT camera systems, as well as integration times, to Meinzer as inputs to the spacecraft attitude control system.

#### **Transponder Development Status:**

**- Karl Meinzer, Others**

Daniels noted that information had been requested, but had not yet been received, on status of the 10 meter transmitter development by the Southern African AMSAT organization.

**ACTION:** Daniels to continue in efforts to secure status information on the 10 Meter transmitter project.

Meinzer confirmed that Werner Haas DJ5KQ has committed to building the 2 m and 70 cm receivers as well as the I.F. matrix. He said that prototyping of the I.F. system is planned to be accomplished by July 1993 and at that time questions concerning AGC implementation would be answered. Bill Tynan questioned having the same gain levels for input and output. Meinzer said that this is to allow direct interfacing of receivers and transmitters.

Sources for the high power transmitters continue to be a problem. While a qualified individual has been located in the Munich area who has indicated an interest in building the 70 cm transmitter, and Meinzer is following up with him, no individual to design and build the 2 m transmitter has been located. The same is true for the S-Band transmitter despite some earlier indications of interest in both Europe and the U.S. Meinzer pointed out that the transmitter development could be broken down into discrete tasks. I.F. technology required to provide output of only about 1 watt is well in hand. The most difficult design is for the final stages which require power output levels well above what had been used in earlier satellites.

High efficiency is a critical requirement to reduce power requirements and heat generation, although continuous full output levels are probably beyond the spacecraft's heat transfer capability. Meinzer said that if individuals or groups can be found to design and build the final stages, Marburg might undertake the modulators.

**ACTION:** All - Continue the search for someone to design and build the 2 m and S-Band transmitters.

**ACTION:** Meinzer - Specifically approach Knute Brendorfer DF8CA to see if he will undertake the S-Band transmitter.

Stilwell and Colson were encouraged to continue the C-Band receiver development into flight hardware.

For the 10 GHz transmitter, a progress report received from Michael Fletcher was distributed that indicated good progress being made by the Finnish group. Semiconductors are available for constructing a complete 10 W minimum transmitter using the proposed phase locked loop and class D/E modulated, amplitude corrected technology. They are targeting on having a working model of one of the four transmitters by May 1993. Considerable additional work is needed on the power supply for the final amplifier and they have requested assistance in

this area. Project Manager Juri Putkonen is currently at the University of Surrey on an exchange program and will be there until Summer.

**ACTION:** All - provide any available information to the Finnish group on Cuk or other power supply designs.

#### **The Master Clock:**

**- Tom Clark, Karl Meinzer**

Clark again proposed incorporating a master clock to provide a standard frequency reference for all transponders. Meinzer responded that a Swiss source for a very precise atomic clock had been investigated but availability appeared questionable so a central frequency reference did not appear likely. Clark, expressing some frustration that this problem had not been more widely communicated, argued that the stability requirement for a master clock did not require extremely precise stability and that it is likely that a quality crystal oscillator with good phase stability would be sufficient for the task. Tom noted that this approach is almost mandatory for the X-Band downlink, as Doppler could move the passband beyond the Amateur Satellite Service frequency allocation. This, coupled with a phase modulator driven from the IHU MA



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counter will would support removing the doppler shift seen on the ground by varying the local oscillator frequencies of the transponders. Meinzer expressed concern that if shifting the frequencies of the transponders required frequency stepping rather than continuous tuning, digital transmissions could be disrupted. Clark felt that this would not be a problem if a phase-resolver approach similar to that employed by the GPS system is used. Meinzer also stressed that, if this approach is taken, each receiver and transmitter should still have its own oscillator which could be used in case of failure of the master oscillator system.

Derwin King pointed out that it would be desirable to have phase coherent transponders to permit propagation experiments.

**ACTION:** Clark to pick up the investigation of incorporating a master clock and make recommendations for removing doppler from the downlink through control of the transponder local oscillators.

#### Weber State Status Report - Ralph Butler

Butler brought the group up to date on current activities at Weber State. He said that stopping the work on the conical adaptor spacecraft following the "Novem-

ber Massacre" had had a noticeable impact on morale, but that a number of smaller tasks are being aggressively pursued. These include fabrication of the Delrin blocks for mounting circuit boards in the equipment modules and fabrication of the modules themselves. He noted that these tasks, while necessary, do not provide the challenge to draw as many of the best students to the project, but expressed confidence that this will turn around when work on the new structure began.

#### Presentations and Discussions with Invited Guests:

*Virginia Polytechnic Institute*  
- Tim Pratt, John Musson

Tim Pratt, a senior faculty member, began by outlining the organization and capabilities of the Radio Communications Group at Virginia Tech. He said that their primary efforts to date has been directed to propagation studies, but that they also have a cellular radio group and responsibility for experiments on the Advanced Communications Technology Satellite (ACTS) project. In addition, he said that they also have antenna capability, including a range. Pratt went on to explain that graduate students working on outside projects were paid \$10 per hour and that the University normally charged an overhead rate of 55%, although special arrangements had been made for non-profit organizations. He also mentioned that the Virginia Technology Center has a program to provide matching funds for activities likely to generate technology with commercial applications.

John Musson followed with his prospective as a graduate student, saying that he has a high degree of interest in the amateur satellites, pointing out that a large number of his fellow graduate students were licensed radio amateurs.

Pratt concluded by saying that while he personally was not interested in working with the Phase 3D Program, he was willing to look for those who might be. He thought that some assistance with check-out tasks might be possible on an informal basis but that undertaking anything like a transmitter development would require a contract.

*University of Alberta - Paul Barrow*

Barrow began by saying that he was representing himself, not the University. He did say that Edmonton had a large ham club and that 6 or 7 members have indicated an interest in helping with Phase 3D. He indicated that his primary interest was in software development and that he is currently involved in beta testing for the TAPR DSP project. He went on to say that

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| Net Designation            | Day       | Time       | Freq.        | NCS         |
|----------------------------|-----------|------------|--------------|-------------|
| <i>International:</i>      |           |            |              |             |
| AMSAT South Pacific        | Saturday  | 2200 UTC   | 14.282 MHz   | ZL1WN       |
| AMSAT International        | Sunday    | 1900 UTC   | 14.282 MHz   | WD0HHU      |
| AMSAT International        | Sunday    | 1900 UTC   | 21.280 MHz   | W8GQW       |
| AMSAT International        | Sunday    | 2300 UTC   | 18.155 MHz   | N4QQ        |
| <i>Regional (USA):</i>     |           |            |              |             |
| AMSAT-NA East Coast        | Tuesday   | 2100 Local | 3.840 MHz    | W8GUS       |
| AMSAT-NA Mid-America       | Tuesday   | 2100 Local | 3.840 MHz    | W0CY        |
| AMSAT-NA East Coast        | Tuesday   | 2000 Local | 3.840 MHz    | K16QE       |
| <i>Local:</i>              |           |            |              |             |
| Atlanta AMSAT Net          | Monday    | 2000 Local | 146.775 MHz  | AB4KN       |
| Colorado AMSAT Net         | Wednesday | 2000 Local | 147.225 MHz  | WD0HHU/WD0E |
| Dallas/Ft. Worth AMSAT Net | Wednesday | 2000 Local | 145.37 MHz   | Various     |
| Detroit AMSAT Net          | Thursday  | 2000 Local | 224.580 MHz  | N8IWJ       |
| Houston Area AMSAT Net     | Tuesday   | 2200 Local | 147.10 MHz   | N5EM        |
| Los Angeles                | Daily     | 0730 Local | 144.144 MHz* |             |
| Los Angeles AMSAT Net      | Wednesday | 2000 Local | 145.440 MHz  | N6TCQ       |
| Miami Area AMSAT Net       | Tuesday   | 2000 Local | 146.925 MHz  | N4IFD       |
| Tucson Area AMSAT Net      | Wednesday | 2000 Local | 146.880 MHz  | NW7N        |
| Washington, DC Area Net    | Sunday    | 2100 Local | 146.835 MHz  | WD8LAQ      |

\*USB

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|----------------------|---------------|----------------------|---------------------------------------------------------------|
| <i>California</i>    |               |                      |                                                               |
| 619/279-3921         | WB6BDY        | Radio Sport          | 300/1200/2400                                                 |
| 714/738-4331         | N6DBF         | Orange Cty Astronomy | 300/1200/2400                                                 |
| <i>Maryland</i>      |               |                      |                                                               |
| 301/593-9067         | G3ZCZ         | Joe Kasser           | 300/1200/2400/9600                                            |
| <i>N. New Jersey</i> |               |                      |                                                               |
| 201/261-2780         | KA2UPD        | Mel Roman            | 300/1200/2400<br>Mon-Fri - 12 AM-12PM<br>Sat-Sun - 9 AM-12 AM |
| <i>Ohio</i>          |               |                      |                                                               |
| 513/427-0674         | Celestial BBS | T.S. Kelso           | 300/1200/2400/9600                                            |
| <i>Texas</i>         |               |                      |                                                               |
| 214/394-7438         | N5ITU         | Jeff Wallach         | 300/1200/2400/9600                                            |



he had contacts at the David Florida Laboratory in Ottawa, a facility set up to do environmental testing of space hardware, and that he would be willing to assist in contacting if needed. He concluded by saying that the University is always looking for co-op student job opportunities.

#### *Southwest Research Institute - Derwin King*

King began with a brief description of Southwest Research Institute, its charter, organization structure and areas of interest. He said that while he personally was not in a position to commit to support of Phase 3D, there were others at SWRI that were very interested in making a contribution. He specifically mentioned an interest in GPS satellite applications and the possibility of flying an experiment on the spacecraft. Responding to questions about the possibility of SWRI's taking on the S-Band transmitter, King said that this would probably not be possible on a no-cost basis. He did indicate that space might be made available for the spacecraft integration effort and said that he would pursue this possibility when he returned.

**Sunday, February 28, 1993**

#### **Phase 3D Master Schedule - Keith Baker**

In his presentation Keith Baker addressed the need for maintaining a detailed activity schedule for the Phase 3D development to provide all of the key players with an understanding of where their activities fit into the overall development schedule and how their hardware deliveries affected the timing of other activities necessary to meet the delivery commitment to ESA. He provided hardcopy examples of an overall project schedule that he had prepared using Microsoft Project Manager software and demonstrated the capability for portraying the relationships between activities and identifying critical paths. He volunteered to serve as the central focal point for maintaining a master schedule for the project, making it clear that the master schedule would only be effective as a management tool if all participants take the effort seriously and provide realistic schedule information on the activities for which they are responsible. Baker's presentation was well received and it was agreed that a master schedule should be developed and maintained.

**DECISION:** A project master schedule to be developed and maintained by Keith Baker using Microsoft Project software incorporating detailed schedule inputs from all participants in the project. Periodic updated schedules will be provided to participants.

**ACTION:** Tynan to approach Microsoft to obtain additional copies of Project Manager.

#### **Interface Control Document - Bill Tynan**

The final presentation was by Bill Tynan on his recommendation to establish a formal Phase 3D Interface Control Document system. Tynan, drawing on his professional experience, had developed an example of the kind of document he was recommending for the purpose of assuring that all physical and electrical interactions between spacecraft systems were identified, completely defined and controlled. He argued that the with the increasing complexity of the Phase 3 spacecraft and the increasingly decentralization of the team, such a document is essential to insure against last minute unpleasant surprises.

In the discussion that followed Tynan's presentation all agreed that definition and control of spacecraft interfaces is essential to successfully conduct of the project. At issue was the degree of formality required and how and where interface control should be accomplished. Meinzer felt that the "Blue" and "Red" books developed and maintained at Marburg for the earlier Phase 3 projects had been effective in maintaining centralized interface control and that the same approach was the most desirable for Phase 3D. He proposed to continue with this process.

**DECISION:** Configuration control to be maintained by AMSAT-DL in the same manner as with the earlier Phase 3 projects.

#### **Closing Activities and Remarks:**

Thanks were given to Dick Jansson and Stan Wood for their efforts in making the administrative arrangements for the meeting and for their hospitality in the evening hours.

A decision on the time and place for the next "Marburg" meeting was deferred pending conduct of several system specific meetings.

Dick Daniels accepted the task of preparing and distributing a record of the meeting including such documentation of the individual presentations as might be available.

The meeting was then adjourned.

#### **Participants in the February 25-28, 1993 Orlando Meeting**

##### **Phase 3D Team Members:**

Keith Baker KB1SF  
AMSAT-NA  
Ralph Butler Weber State Univ.

|               |                     |
|---------------|---------------------|
| Tom Clark     | W3IWI<br>AMSAT-NA   |
| Dick Daniels  | W4PUJ<br>AMSAT-NA   |
| Dick Jansson  | WD4FAB<br>AMSAT-NA  |
| Peter Guelzow | DB2OS<br>AMSAT-DL   |
| Karl Meinzer  | DJ4ZC<br>AMSAT-DL   |
| Miki Nakayama | JR1SWB<br>JAMSAT    |
| Bob Stilwell  | Johns Hopkins Univ. |
| Bill Tynan    | W3XO<br>AMSAT-NA    |
| Stan Wood     | WA4NFY<br>AMSAT-NA  |

#### **Invited Guests:**

|                 |                                             |
|-----------------|---------------------------------------------|
| Scott Bertin    | Embry Riddle Univ.                          |
| Chris Edwards   | " "                                         |
| Robert Janousek | " "                                         |
| Brian Wolf      | " "                                         |
| Paul Barrow     | VE6ATS<br>University of Alberta             |
| John Musson     | WD8MQN<br>Virginia Polytechnic<br>Institute |
| Tim Pratt       | " "                                         |
| Derwin King     | W5LUU<br>Southwest Research<br>Institute    |

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# SAREX QSL Information

By: Frank H. Bauer, KA3HDO  
AMSAT V.P. for Manned Space Programs

In less than two years, five Shuttle Amateur Radio Experiment (SAREX) missions have been flown. For every mission, a different amateur radio club or organization has graciously volunteered to distribute the QSL cards. Keeping track of every QSL distributor can be somewhat confusing, so for your convenience AMSAT has compiled the addresses of the QSL distributors for the STS-35, 37, 45, 50 and 47 missions. These are shown below.

|        |                                                                |        |                                                                                      |
|--------|----------------------------------------------------------------|--------|--------------------------------------------------------------------------------------|
| STS-35 | Frank Bauer, KA3HDO<br>9609 Tuckerman Ct<br>Seabrook, MD 20706 | STS-50 | Dayton Amateur Radio<br>Association<br>STS-50 QSL<br>P.O. Box 44<br>Dayton, OH 45401 |
| STS-37 | Frank Bauer, KA3HDO<br>9609 Tuckerman Ct<br>Seabrook, MD 20706 | STS-47 | Jay Apt, N5QWL<br>806 Shorewood Drive<br>Seabrook, Texas 77586                       |
| STS-45 | Sterling Park ARC<br>P.O. Box 599<br>Sterling, VA 22170        |        |                                                                                      |

To receive a QSL, SAREX participants must include the QSO information (e.g. date, time in UTC, frequency, mode) which documents the contact or listener report. In addition, a large, business sized SASE is required for those who wish to receive a card. No cards will be distributed without the proper postage affixed or sufficient IRCs included.

The status of the various cards and their distribution follows:

| Mission | Ham Crew/Call                                                                                      | Launch | QSL Distribution Status                                                                                  |
|---------|----------------------------------------------------------------------------------------------------|--------|----------------------------------------------------------------------------------------------------------|
| STS-35  | Ron Parise/WA4SIR                                                                                  | 12/90  | Distribution Complete. FINAL DEADLINE to submit card 5/1/93.                                             |
| STS-37  | Ken Cameron/KB5AWP<br>Jay Apt/N5QWL<br>Linda Godwin/N5RAX<br>Steve Nagel/N5RAW<br>Jerry Ross/N5SCW | 4/91   | All who included SASE's for STS-37 should have received their QSL. FINAL DEADLINE to submit card 9/1/93. |
| STS-45  | David Leestma/N5WQC<br>Brian Duffy/N5WQW<br>Kathryn Sullivan/N5YYV<br>Dirk Frimout/ON1AFD          | 3/92   | All who included SASE's for STS-45 should have received their QSL. FINAL DEADLINE to submit card 9/1/93. |
| STS-50  | Dick Richards/KB5SIW<br>Ellen Baker/KB5SIX                                                         | 6/92   | QSL distribution just beginning.                                                                         |
| STS-47  | Jay Apt/N5QWL<br>Mamoru Mohri/7L2NJY                                                               | 9/92   | QSL card development currently underway.                                                                 |

## Acknowledgments

As stated, a different amateur radio club or organization volunteers to distribute the QSL cards for each SAREX mission. AMSAT sincerely appreciates the efforts these amateur radio groups have expended to serve YOU, our SAREX enthusiasts. The SAREX team would like to recognize these groups for all their support. These groups include the Washington Area AMSAT Group and members of the Goddard ARC for their help in the distribution of the STS-35 and STS-37 cards, the Sterling Park ARC, lead by Dick Maylot, W4LMJ, for their support in distributing the STS-45 QSL cards, the Dayton Amateur Radio Association, lead by Keith Baker, KB1SF, for their support in distributing the STS-50 QSL cards, and the JSC ARC, lead by Jay Apt, N5QWL, for their commitment to distribute the STS-47 cards. In addition, we would like to especially recognize Tom Clark, W3IWI, for his outstanding support in compiling, documenting, and producing mailing labels for the STS-35 packet QSOs. ■

# Sidebar For First Paper Model

By: Walter Daniel, KE3HP

I used to be a college professor; I taught spacecraft engineering courses. To help my students visualize concepts such as antenna pointing and sun angle, I made paper models of various satellites. Even though I'm back in the real world, I find models useful for discussions with other engineers. For example, I recently had a conversation with WD4FAB regarding sun angle for the Phase 3D spacecraft. I had constructed a case in my mind in which the solar panels would receive no sunlight, but WD4FAB disagreed with me. After using a Phase 3D model and a globe, I realized that I was incorrect because I had not visualized the orbit geometry properly.

I have begun to design paper models of amateur radio satellites. If readers express interest, models like the one of AO-16 in this issue could appear regularly. You can use these models to help spread the word about AMSAT by making copies and distributing them at hamfests and club meetings. You can also build extra models and give them to teachers and students for use in science classes.

While instructions are printed on the model page, there are a few hints that I would like to pass along:

- Photocopy the model onto the heaviest card stock you can find (e.g., report covers).

- Most plain paper copiers now have a manual feed input with a straight path so the copier won't jam on thick stock.

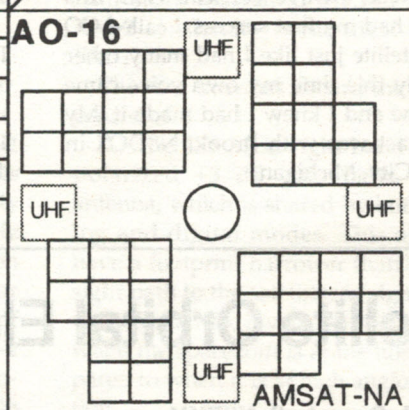
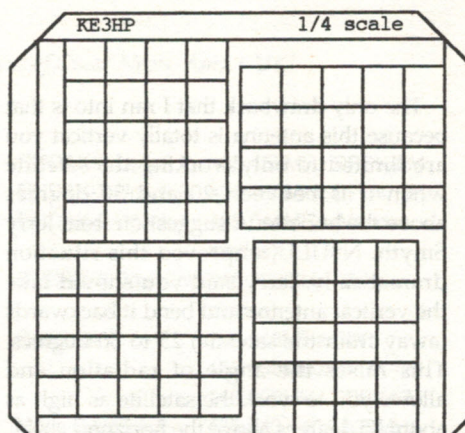
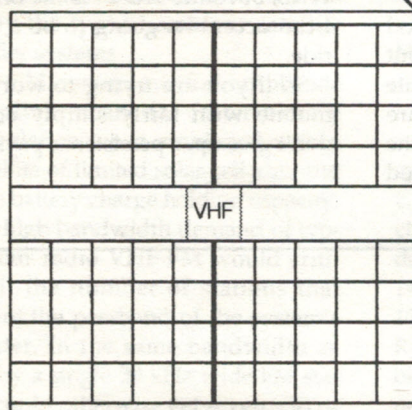
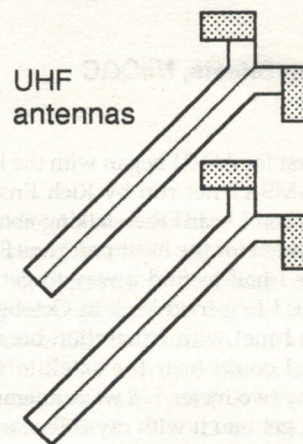
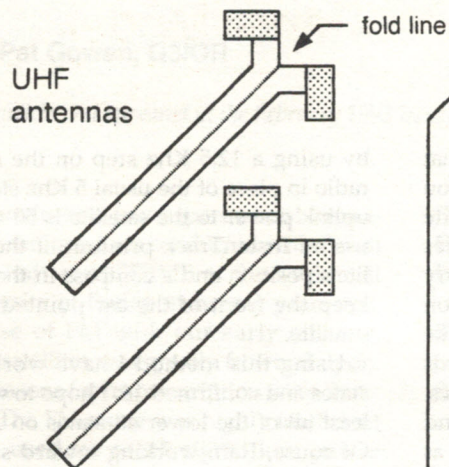
- Scissors are helpful, but I make most of my cuts with a sharp hobby knife against a straightedge. Use the same knife and straightedge to lightly score edges to be folded.

- Use glue sparingly so that it will dry quickly.

- Find a drawing or photograph of the spacecraft in the Journal or The Satellite Experimenters Handbook to use as a guide during assembly.

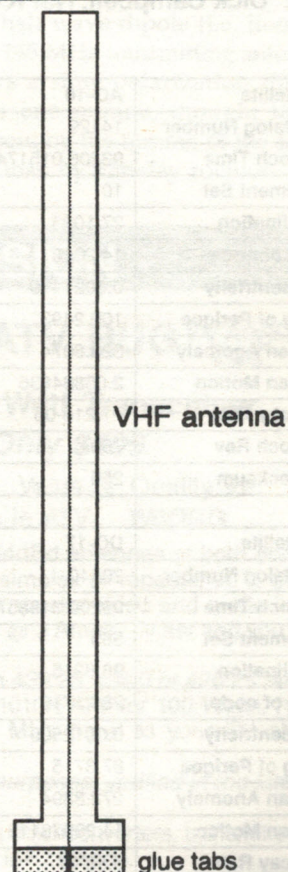
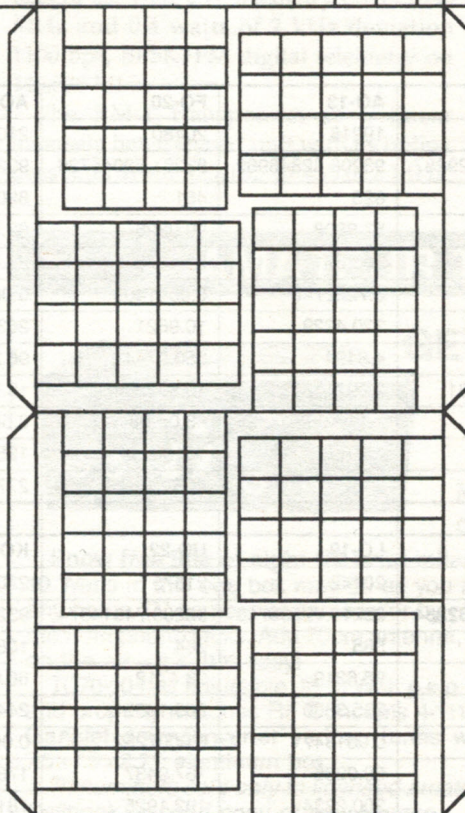
Thanks to the indefatigable AMSAT-NA Vice President for Engineering Dick Jansson WD4FAB for design drawings and advice. By the way, when was the last time that you can remember a (former) college professor admitting he was wrong? ■





## INSTRUCTIONS

1. Photocopy this page onto a sheet of heavy stock paper
2. Lightly score fold lines with a sharp hobby knife
3. Cut all pieces from the sheet
4. Cut the thick line between the two glue tabs on the bottom of the VHF antenna. Fold the antenna along the dotted line and glue. Keep the glue tabs perpendicular to the antenna.
5. Fold each UHF antenna along its dotted line and glue. Keep the glue tabs perpendicular to the antenna.
6. Fold the body along the edges and tab lines, then assemble.
7. Glue the UHF antennas to the body and let dry.
8. Glue the VHF antenna to the body.





# How To Work AO-21 From Your Mobil

By: John Sheets, N8QGC

My quest for AO-21 began with the local Detroit AMSAT net run by Rich Ensign, N8WJ. When I heard Rich talking about a satellite which for the most part runs FM, I just knew I had to find a way to get my station on. I first tried back in October of 1992, but I met with frustration because although I could hear the satellite very well on my two meter 5/8 wave antenna, I could not get into it with my collinear 440 antenna. That's when I switched to a homebrew 1/4 wave vertical. With this antenna I had my first success. I called CQ on the satellite just like I had many other times only this time my own voice came back to me and I knew I had made it. My first contact was with Brook, N8OCX in Traverse City, Michigan.

The only drawback that I ran into is that because this antenna is totally vertical you are limited to only working the satellite when it is between 20 and 50 degrees above the horizon. A suggestion from Jerry Smyth, N8ULU, improved this situation dramatically. Jerry said you should take the vertical antenna and bend it backwards (away from the satellite) 25 to 30 degrees. This raises the angle of radiation and allows you to work the satellite as high as about 75 degrees above the horizon.

The equipment that I use is a Kenwood TM-731-A that has been modified for out of band transmit in the 435 Mhz satellite sub-band. The frequencies that I use are 435.015 on the uplink and 145.9875 on the downlink. the 145.9875 is accomplished

by using a 12.5 Khz step on the mobile radio in place of the usual 5 Khz step. My uplink power to the satellite is 50 watts. I use an InstantTrack printout of the satellite's position and a compass in the car to keep the front of the car pointed at the satellite.

Using this method I have worked 26 states and confirmed 16. I hope to work at least all of the lower 48 states on AO-21. Of course, I am working toward satellite WAS, but since AO-21 is the only satellite I can access its going to be a long hard ride.

So if you are trying to work satellite mobile with fairly simply equipment, don't give up.... persistence pays. ■

## Satellite Orbital Elements

By: Dick Campbell, N3FKV

| Satellite      | AO-10          | RS-10/11       | AO-13          | FO-20          | AO-21          | RS-12/13       | AO-16          |
|----------------|----------------|----------------|----------------|----------------|----------------|----------------|----------------|
| Catalog Number | 14129          | 18129          | 19216          | 20480          | 21087          | 21089          | 20439          |
| Epoch Time     | 93206.01517440 | 93209.49629287 | 93206.62846982 | 93201.52045726 | 93210.63265305 | 93207.07946854 | 93200.26347958 |
| Element Set    | 10             | 635            | 625            | 451            | 820            | 411            | 563            |
| Inclination    | 27.1023        | 82.9209        | 57.8808        | 99.0326        | 82.9420        | 82.9224        | 98.6210        |
| RA of node     | 14.2310        | 208.0752       | 303.8211       | 51.4678        | 21.4116        | 253.2736       | 285.0949       |
| Eccentricity   | 0.6021479      | 0.0010989      | 0.7222740      | 0.0541409      | 0.0033930      | 0.0028626      | 0.0012487      |
| Arg of Perigee | 100.2493       | 196.5739       | 320.4229       | 10.9621        | 263.5074       | 299.6709       | 88.0964        |
| Mean Anomaly   | 328.8974       | 163.5032       | 4.8494         | 350.2744       | 96.2198        | 60.1600        | 272.1649       |
| Mean Motion    | 2.05884636     | 13.72320931    | 2.09717309     | 12.83220462    | 13.74522565    | 13.74024613    | 14.29841825    |
| Decay Rate     | -1.21e-06      | 8.8e-07        | 1.11e-06       | -8.0e-08       | 8.5e-07        | 1.8e-07        | 4.7e-07        |
| Epoch Rev      | 7604           | 30551          | 3916           | 16160          | 12527          | 12386          | 18202          |
| Checksum       | 250            | 321            | 300            | 265            | 277            | 302            | 327            |
| Satellite      | DO-17          | WO-18          | LO-19          | UO-22          | KO-23          | MIR            | ARSENE         |
| Catalog Number | 20440          | 20441          | 20442          | 21575          | 22077          | 16609          | 22654          |
| Epoch Time     | 93200.31985796 | 93210.22582284 | 93210.22505746 | 93209.74914374 | 93206.06275607 | 93210.81908771 | 93205.94934774 |
| Element Set    | 565            | 568            | 565            | 264            | 108            | 206            | 13             |
| Inclination    | 98.6215        | 98.6216        | 98.6219        | 98.4712        | 66.0764        | 51.6203        | 1.1916         |
| RA of node     | 285.3710       | 295.2027       | 295.3860       | 285.1895       | 244.8799       | 5.4136         | 122.7676       |
| Eccentricity   | 0.0012509      | 0.0013101      | 0.0013471      | 0.0007252      | 0.0002837      | 0.0004148      | 0.2935927      |
| Arg of Perigee | 87.3715        | 61.2887        | 60.0285        | 167.9437       | 178.5049       | 263.8691       | 147.8536       |
| Mean Anomaly   | 272.8894       | 298.9611       | 300.2234       | 192.1925       | 181.5978       | 96.1866        | 237.2358       |
| Mean Motion    | 14.29978118    | 14.29958954    | 14.30049234    | 14.36841017    | 12.86279648    | 15.58987373    | 1.42201630     |
| Decay Rate     | 5.8e-07        | 5.4e-07        | 5.8e-07        | 6.3e-07        | .00000000      | 7.546e-05      | -4.9e-07       |
| Epoch Rev      | 18204          | 18346          | 18347          | 10663          | 4471           | 42578          | 111            |
| Checksum       | 330            | 318            | 280            | 320            | 322            | 322            | 285            |



# OSCAR-21/RS-14 RUDAK on FM Transponder Mode

By: Pat Gowen, G3IOR

[This article first appeared in the February 1993 issue of Oscar News, Amsat-UK]

Apart from a few experimental broadcast technique tests conducted with Bandi Gshwindt as HG5BME at the Technical University of Budapest twenty years ago, the use of FM with our early amateur radio satellites was greatly frowned upon. The reasons for its proscription were that:

(1) The FM mode was highly inefficient when used for weak signal low power long distance communications, as then limited by the typical amateur satellite transponder systems.

(2) The FM continuous full amplitude carrier uplink meant far faster battery charge depletion when employed with a small satellite of limited solar cell area and very finite battery charge holding capacity.

(3) The high bandwidth demand of typical amateur radio VHF-FM would critically limit the number of stations that could share the passband of the system's transponder. In the same bandwidth as taken up by a single 20 kHz wide FM station, one could otherwise get seven SSB or twenty CW stations without excessive conflict.

This situation changed with the 29 January 1990 North Cosmodrome Plesetsk launch of the joint AMSAT-DL and AMSAT-UA AMSAT-OSCAR-21 and RS-14 assembly aboard the Russian GEOS research satellite INFORMTR-1, NASA Cat.No. 21087. It placed the spacecraft into a slightly elliptical quasi-polar orbit with an inclination of 83 degrees, a 1000 km apogee and a 105 minute period. RS-14/OSCAR-21 draws its power supply from the main GEOS satellite, so with up to 100 W permitted, one of the main factors denying FM is overcome.

OSCAR-21/RS-14 carries a number of highly versatile sub-systems. The on-board Russian RM-1 and RM-2 analog (SSB & CW) transponders have extremely sensitive 70 cm analog receivers with very strong 2 m downlinks. They utilize the following listed frequencies:

|                   |                                                               |
|-------------------|---------------------------------------------------------------|
| Beacons           | 145.822MHz CW.<br>145.952MHz BPSK/FM.<br>145.983MHz BPSK/SSB. |
| Mode B Uplink 1   | 435.022 - 435.102MHz<br>SSB, CW.                              |
| Mode B Downlink 1 | 145.852 - 145.932MHz<br>SSB, CW, inverting.                   |
| RUDAK-2 Uplink 1  | 435.016MHz AFSK/FM.                                           |

|                   |                                                              |
|-------------------|--------------------------------------------------------------|
| RUDAK-2 Uplink 2  | 435.155MHz BPSK/FM.                                          |
| RUDAK-2 Uplink 3  | 435.193MHz BPSK/FM.                                          |
| RUDAK-2 Uplink 4  | 435.041MHz (Various<br>modes)                                |
| RUDAK-2 Downlink  | 145.983MHz (Various<br>modes)                                |
| Beacons           | 145.948MHz CW.<br>145.838MHz BPSK/FM.<br>145.800MHz BPSK/FM. |
| Mode B Uplink 2   | 435.043 - 435.123MHz<br>SSB, CW.                             |
| Mode B Downlink 2 | 145.865 - 145.946MHz<br>SSB, CW, inverting.                  |

The beacons and telemetry of the RM-1 system have eight channels of 0.2 watts CW telemetry on 145.822 MHz and thirty channels of 1100 bps BPSK/FM 2 kHz deviation digital telemetry of 0.4 watts on 145.952 MHz. The 3 Watt BPSK 1100 or 1200 bps AX.25 digital telemetry of RUDAK-2 is on 145.983 MHz. The RM-2 beacons and telemetry have eight channels of 0.2 watt CW telemetry on 145.948 MHz and 0.4 watts of 2 kHz deviation 1100 bps, BPSK/FM digital telemetry on 145.838 MHz.

The RM-1 transponder is a linear inversely heterodyned unit with its uplink passband from 435.102 to 435.022 MHz,

and its 10 watt 80 kHz wide downlink passband from 145.852 to 145.932 MHz to the -3 dB points. A maximum of 100 Watts eirp is required for the uplink, and in practice 10 W will usually suffice.

The RM-2 transponder is also linear inversely heterodyned. It has an uplink passband from 435.123 to 435.043 MHz, and it's 80 kHz wide 10 watt downlink runs from 145.866 to 145.946 MHz. The RM-2 sensitivity is identical to that of RM-1.

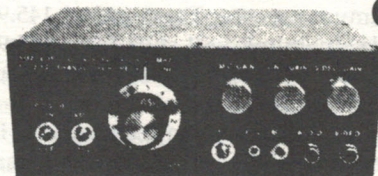
The two antennas aboard the spacecraft consist of:

(1) The 435 MHz right hand circularly polarized +3 dB gain helix receiving antenna, which is shared by both the analog and digital modes. This appears to have a footprint narrower than the line of sight path to the satellite, as signals are far weaker than the inverse square law allows when the spacecraft is at the horizon compared to when it is at high angles of elevation.

(2) The half wave dipole (i.e. linearly polarized) 145 MHz transmitting antenna. This shows a slow polarization roll of more than one minute, thought to be brought about by the turning of the satellite rather than by Faraday rotation. The

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use of circular polarization by the ground station helps to overcome the worst of the roll pattern fadeouts.

AMSAT-DL designed RUDAK-2 and its sub-systems aboard the spacecraft to act as a test-bed for the forthcoming unit on PHASE 3D. The original RUDAK-1 aboard AMSAT-OSCAR-13 sadly failed to function soon after launch. RUDAK-2 is a highly advanced system providing a host of digital modes. Its digital transponder holds a digipeater with AX.25 store and forward providing packet radio communications, a telecommunications experiment with digital signal processing of up to nearly 20 kHz. and a 1 MByte ramdisk.

Uplinks to this system are:

RX-2 435.155 MHz (AFC) 2400 bps, BPSK, Biphase-S

RX-3a 435.193 MHz (AFC) 4800 bps, RSM

RX-3b 435.193 MHz (AFC) 9600 bps, RSM

RX-4 435.041 MHz (digital AFC) RX for RTX-DSP

The downlink frequency is on 145.987 MHz, and its 3 Watts of RF output provide a very strong signal. This downlink can be switched to several operating modes:

Mode 1: 1200 bps, BPSK, NRZI, (NRZ-S) (like FO-20Us)

Mode 2: 400 bps, BPSK, Biphase-S (like Oscar-13's beacon)

Mode 3: 2400 bps, BPSK, Biphase-S

Mode 4: 4800 bps, RSM, NRZIC (Biphase-M) (as 4800 bps uplink)

Mode 5: 9600 bps, RSM, NRZI (NRZ-S)+Scraable (as 9600 bps u/l)

Mode 6: CW keying (used only for special evers)

Mode 7: FSK (F1 or F2B), e.g. for RTTY, SSTV, FAX, etc. (This also is normally used only for special events)

Mode 8: FM modulated by D/A signals from DSP-RISC processor.

It is this latter mode on RUDAK uplink 1 that is providing the present 435.016 MHz to 145.987 MHz FM speech transponder facilities that we are now hearing for most of the time of a pass between the one minute of 1200 bauds telemetry and any 3 minute duration uploaded speech messages. In practice due to the Doppler shift the single 435.016 MHz conventional FM uplink varies from a need to transmit up from 435.007 MHz at the AOS of an overhead pass, through nominal at TCA, up to 435.025 MHz at LOS time to give optimum capture. The nominal 145.987 MHz downlink will shift from 145.990 MHz at AOS down to 145.984 MHz on a maximum elevation pass.

Such a system like any conventional FM 'repeater', will only support and transpond a single station at any one time. Sadly, many users do not seem to recognize this fact, as in Europe in particular, many stations attempt to use the transponder at the same time, resulting only too often in mutual QRM. Whilst weaker mobile and portable stations using less than 10 watts ERP have been worked at light loading times, more often the FM capture effect comes into play, with high power stations tending to monopolize the system by repetitive use. Furthermore strong non-amateur stations in the 70 cm band appear to be deafening the input and causing false command problems that

automatically switch in the -12 dB attenuator on the receiver input.

During recent special tests when the command station switched out the attenuator, considerable improvement resulted. Many North American stations were worked when the satellite was barely above the horizon, and I had a QSO in which DB20S lowered his power to only 1 Watt. He was still perfectly readable! When the attenuator is in circuit, some 50 Watts to a 12 element RHCP Yagi is found to be needed, and even this is only effective when the satellite elevation is greater than 10 degrees.

The FM mode is highly popular, with some eight hundred station's call signs already heard, most of whom have never been noted before on satellites. The majority of the stations are in Western Europe and the USA, but several of the 'rarer' DXCC countries (such as TR8GA and YI1BGD) are regularly active. It is hoped that this new mode providing intercontinental communications for the many stations already equipped will bring many more to the field of OSCAR satellites. ■

## CALL FOR PAPERS 1993 AMSAT ANNUAL MEETING AND SPACE SYMPOSIUM October 7, 8, & 9

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If you would like to submit a paper, simply compose a short abstract describing the purpose and scope of the paper. Abstracts are due by July 30, 1993. The final draft of the papers are then due by August 27, 1993. Please mail all submissions to the address below.

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# You, too, can contact space!

## QRP to the satellites

By: Michael Bass, N7WLC/5

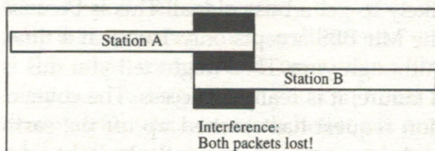
It doesn't take a whole lot of power or fancy equipment to work satellites in earth orbit. For two of them, it takes no more power or sophistication than a hand-talkie. If you are new to amateur radio, like I am, your budget doesn't allow getting the latest and greatest in satellite gear. But that shouldn't stop you from getting involved in this fascinating aspect of ham radio. To talk to the Shuttle or to the Russian space station, Mir ("peace" in Russian), all you need is a 2-meter hand-talkie and a good antenna — sorry that rubber duck just won't make it, although you can hear Mir with it. Since both of these "satellites" use packet radio most of the time, the standard packet radio setup is also required, a TNC (terminal node controller) and a computer. The computer is especially handy to predict when Mir or the shuttle will be over your particular location. When I first started talking about making contact with Mir, most hams couldn't believe I could make a contact to space with only 5 watts. 2-Meter radiation travels mostly by line-of-sight, and there is nothing obstructing the path when going straight up. Power is only a consideration when trying to "bend" your signal around a corner.

### A Little Background

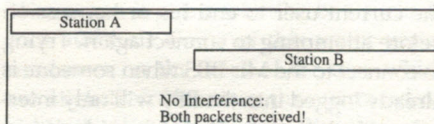
Before trying to contact Mir, it is important to be aware of how FM transmissions work and interfere with each other. Listen to the local repeaters and hear what happens with two people "double" with each other. If the stations have the same power, garbled signals result. If one station is weaker than the other, only the stronger station is heard, although the signal quality is poorer. This means when contacting Mir at low power, say 5 watts, your signals will be drowned out by the big guys. One might think that cranking up the power will solve the problem. Not so. This is only a problem if both stations are transmitting at the same time. This is the key.

The second thing to keep in mind is how packet radio works. The TNC will not transmit when it hears someone else transmitting. When talking to the satellite, the earth-bound station hears almost no one else. So the ground station thinks it is free to transmit at almost any time. But the

satellite hears everyone in several states at once. This means that when you are transmitting to Mir, another station several hundred miles away, hearing a clear channel, might attempt to transmit. Those signals have a chance of interfering with each other. On Mir, the cosmonauts hear pileup on a grand scale.



But there is a solution to this problem. If the packets are shorter, by sending smaller lines or setting the TNC to send smaller packets, both packets can get through. The TNC command "PACLEN=40" will do this automatically. The shorter the time you transmit, the less likely there will be interference.

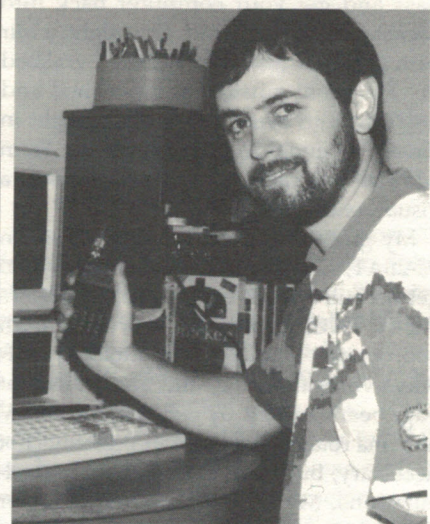


If we apply this technique to satellite communication, a QRP station will be able to talk to the birds just as easily as a more powerful station. (Of course there is a limit to how well this might work, but cutting lines down from 80 characters to 30 or 40 does seem to help quite a bit.)

### The Ground Station

The basic packet station, even with a 5-watt hand-talkie as the transmitter is sufficient to get to Mir. The main, and always most important, consideration is your antenna. The rubber duck that came with your HT isn't sufficient to get to Mir. However a half-wavelength vertical dipole is. I put this antenna on a 20 foot mast on my roof and was able to make a connection to the Mir space station. This set-up does limit you to the center part of the satellite pass, the center 4-5 minutes of the 10-minute horizon-to-horizon pass. But the advantages are that you don't need an expensive antenna rotator and elevator. Just knowing when the satellite is visible is sufficient to get on the air.

If you want to get that connection going from the beginning of the pass, you'll need to use a directional antenna. A



Michael Bass, N7WLC/5

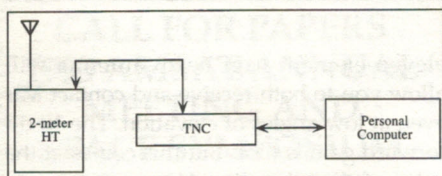
eleven-element yagi beam antenna will allow you to both receive and contact Mir even at low angles of elevation. The 10 dB forward gain is nice. But this comes at the price of directionality. Now you have to worry about where the satellite is in the sky in addition to when it is visible. A cheap solution to this problem is to buy an antenna rotator. Although this does not give you control of the elevation, a little thought can help you out of that problem. The radiation pattern for an 11-element beam is approximately 60 degrees wide. So if you pitch the beam up about 25-30 degrees, you get good coverage up to 50 or 60° elevation. This orientation still allows good ground coverage for hitting those distant repeaters. All without having to adjust the elevation. I haven't gone to this trouble yet. I have made packet contacts with Mir and the Shuttle with the beam pointed to the horizon. One problem with pointing the antenna to the horizon, is that when the space station is directly over head, the received signal strength is actually lower due to the directionality of the beam antenna. Fortunately the amount of time Mir is directly over head is very small, so this does not present much of a problem.

Satellite tracking software is particularly useful. These programs calculate where and when the satellite will be visible at your location. The satellite elements (called Keplerian elements) which tell where the satellite is, are available on the Internet as well as on most packet bulletin boards. With a recent update of the elements — they are good for a little over one month, unless mission controllers adjust the orbit. You can then predict where and when the satellite will be over your location. With a little preparation, you can be ready for the



pass and get your computer back into packet mode to copy Mir. One night, a Mir pass occurred just after sunset. I grabbed my HT, went outside, and watched and heard Mir go over. It was quite bright in the sky — about as bright as Venus. So in addition to a radio contact, I have made a visual contact with Mir.

My ground station consists of an Icom IC-2SAT, 12v power supply or battery (to get the full 5 watts out of the HT), AEA's PK-88 TNC, Zenith Z-158 with a math coprocessor (PC/XT compatible), a half-wave vertical dipole, and an 11-element yagi beam turned by a Radio Shack TV antenna rotator. A math coprocessor is not necessary, but really speeds up orbit calculations. My PC/XT was much faster than a 286 machine without a coprocessor. Here's a block-diagram of my station:



### Operating Specifics

The Mir space station and the Space Shuttle both transmit on 145.550 MHz. Mir runs simplex on 145.550 MHz, but the Shuttle uses a slightly different uplink frequency. A number of articles in AMSAT Journal and other magazines talk a lot about doppler shifts when working satellites. Because FM is a wider transmission mode than CW or SSB, I haven't had to worry about the doppler shift.

To copy Mir or the shuttle, adjust the TNC to display all packets ("MONITOR 6" command). Although some of what is received is unintelligible, it is reassuring to know that everything is working properly. Another good trick is to set the TNC to pass all packets, even if there are mistakes in the packet. Normally the TNC will not display packets received with errors. But when Mir is low on the horizon, it is sometimes nice to see something — anything — especially when I hear the packets on audio. Very early and late in the pass, I set my TNC with "PASSALL ON". Most of the time there is only a 1 or 2 character mistake in the packet, so I can still read the text of the message. (Here, again, is a place where smaller packet size might help. But since Mir is sending these packets, mere mortals have no control over them. When high in the sky, Mir comes in with S9 signal strength and transmission errors are not a problem.) When you hear packet activity, then you can tell what call-sign to use. The current Mir bulletin board station (BBS) is R2MIR-1. When the cosmonauts change, the call sign changes as well.

But you need only monitor for a few minutes before you realize which call to use. The BBS always has the SSID (secondary station identifier) of -1.

I call the Mir packet station a BBS, but it is not a full-fledged packet bulletin board. It is more of a personal packet mail box similar to the mailbox on an earth-bound TNC. Don't try to connect to the Mir BBS unless you hear packet activity first. Sometimes the cosmonauts will be using this frequency for voice contacts. Sometimes, for power budget reasons, the packet station is off the air. So make sure you monitor the frequency before you start transmitting.

When you connect, you are more than likely to get a busy signal. This is because the Mir BBS accepts only 1 user at a time. Although your TNC might tell you this is a failure, it is really a success. The connection request has reached up off the earth and was received, correctly I might add, by the Mir TNC. You then were able to receive the "busy" signal from Mir. It might not be the most interesting QSO in the world, but you were heard by Mir. This is proof positive that your QRP station has the power to reach out to orbit. If the BBS is busy, it is best to patiently watch the current QSO in progress and wait for the current user to end his or her session before attempting to connect again. Trying to connect to the Mir BBS when someone is already logged into the BBS will only interfere with the person and delay when they will be able to disconnect.

While connected, it is best to send and receive messages as fast as possible. Preparation is important. I usually have a message (with short lines) already composed on disk waiting for the connection. Then I send this file to the TNC (I use the ASCII dump feature of my terminal program), so that no time on Mir is wasted waiting for my slow typing. Especially since I am running QRP, I need to act fast. The big boys might come on line and start clobbering my packets. Remember the Mir BBS is a shared resource and is only overhead for 10 minutes at the most. While I am logged into this BBS, no one else can. So I make sure my contacts are short, and I log off before Mir leaves my portion of the sky. (If someone doesn't disconnect, Mir will "time out" the connection — but only after 10 minutes.)

### The Contact

Sometimes even all the technical preparations won't help make that connection to the Mir BBS. If there are a lot of other hams trying to get on the BBS, and there usually are, you have to find a time when there aren't so many people. My first connection

to the BBS occurred early in the morning (6 AM local time). I think I was still half-asleep. I was too tired to be excited when I got the "Connected to U8MIR-1" message. But I had my message already prepared and my terminal program was set to record the entire session. So later after I woke up, I was able to see I had made a connection and left a message for U8MIR.

```

cmd:timestamp on
cmd:monitor 6
cmd:da
Daytime 17-Apr-92 06:12:31
cmd:c u8mir-1
*** U8MIR-1 busy
      Busy...wait till someone disconnects
*** DISCONNECTED: U8MIR-1

06:15:55 U8MIR-1*>WA7YAZ (DM,F)
06:15:56 U8MIR-1*>N6JLH (D,P)
      Aha! N6JLH just disconnected
06:15:58 U8MIR*>KA7KSN (UA,F)

cmd:c u8mir-1
*** CONNECTED to U8MIR-1
      I did it!
Logged on to U8MIR's Personal Message System

CMD (B/H/J/K/KM/L/M/R/S/SR/V/?)>
s u8mir

Subject:
Greetings from SE Washington State!
Message:
I'm using a 5 W handheld to make this connection. Do you use voice for QSO?
73s de Mike N7WLC

Message saved as Msg # 372
CMD (B/H/J/K/KM/L/M/R/S/SR/V/?)>
b
- Logged off
*** DISCONNECTED: U8MIR-1
cmd:

06:17:35 U8MIR-1*>KF6PM (UA,F)
06:17:35 U8MIR-1*>KF6PM [I;0,1]:
  
```

I made this message was left two months after getting my license. Now I probably wouldn't have asked if the cosmonauts make voice contacts. From my reading and listening, I know they do make voice contacts on occasion. Once, I heard a voice QSO someone was having with Mir while in my car. Imagine my surprise when I heard Mir using the rubber duck on the HT from inside my car!

Of the 2-meter amateur radio space stations, Mir is the easiest to contact. The output power and antenna gain for the Shuttle is lower than Mir, making it more difficult to contact. Mir orbits continuously while the Shuttle carries SAREX (Shuttle Amateur Radio EXperiment) only occasionally. Mir's high inclination orbit makes contacts possible throughout most of North America. Running simplex with Mir is much easier to program into your 2-meter rig than the strange offsets used to contact the Shuttle. It is interesting to see how little power can be used to make satellite contacts. ■



# Heard on the Downlink

By: John Hansen, WA0PTV

Last issue's column generated a considerable amount of interest, some controversy, and some additional suggestions. So I will begin this month by revisiting some of the topics from last month's column.

## 40 CX Reprise

I received a number of communications concerning the KLM 40CX 70 cm antenna. The most comprehensive was from former AMSAT President Vern Riportella, WA2LQQ. He commented on a number of issues raised in the article and made some additional suggestions.

In particular, he noted that the September 1, 1986 issue of the *Amateur Satellite Report* (one of the previous incarnations of this Journal) contained a description of a mechanism to mount the coax on the 40CX without causing damage to the connector. The suggestion was similar to that mentioned in last month's column with one alteration. The ASR piece suggests using a right angle N adapter on the 40CX box to make it easier to route the coax. If you adopt this idea make sure you get a very good quality adapter. There was a piece in QST a few years ago about how poorly made some of these adapter are. A satellite operator in Buffalo tore his whole station apart a few years ago looking for a fault which turned out to be a bum right angle 'N'.

Rip also made some suggestions about drilling holes in driven elements of the 40CX. He noted that you must be careful about selecting the location to drill and the size of the holes. He suggested avoiding drilling holes where the aluminum bends because the bending places stress on the metal which might cause stress cracks to form. Then, under constant wind vibration it is possible that could result in a fracture of the entire element. Rip reports that this did happen to him with the larger 2 meter KLM 22C, but as yet no one reports this experience with the 40CX. Rip also notes that the holes must be large enough to overcome the surface tension of the water and thus to let it flow out, but should not be so large as to weaken the elements. He suggests two holes that are 3/32" in diameter.

Rip also wonders whether taking the water out of the elements will actually have any effect on the swr. After all most of the current should be flowing on the outside of the element anyway. The same

question was raised in a packet note sent in by WB2UZR. As I thought about it I began to wonder if they weren't correct. However, I had heard this tip from a couple of different people on AO-13 and when my SWR went through the roof one day, I climbed up, drilled the holes and found the swr was normal again. It wasn't cold enough to be iced up and I had made no other changes to the antenna or feedline. Anyone else have any thoughts on why this appears to make a difference?

Rip also commented on sealing the relay box, noting that if you can't seal it completely, you are much better off providing a mechanism for the water to drain. Here is why: Even if you seal it so it is water tight, if it is not air tight water vapor will enter when air enters. The explanation is very similar to the one provided in this column a few months ago with respect to 9913 coax. The box sucks! (well, sucks water). As the air warms in the day it expands and leaves the box. Then when it gets cooler the box sucks in cool moist air. Some of this water vapor condenses on the sides of the box, which are slightly cooler than the surrounding air. Voila! Water in the box. Rip suggests a 1/4 inch hole drilled in the corner of the bottom side of the box, to assure that the water has an exit.

I also received some letters with additional suggestions on mounting the 40CX so it would be better balanced. Eric Rosenberg, WD3Q, advises that he would not remount the antenna by drilling through boom because it would significantly weaken the boom. He tried this and the antenna fell over in a windstorm because the U-bolt tore through the metal! He obtained a surplus mounting plate from a KLM 14C and has been happy with the results. It occurs to me that those of us who do not have surplus 14C mounting plates lying around might find it not all that difficult to fabricate one. Ron Long, W8GUS (and Journal Editorial Staffer) sent me a note that suggested doing just this, but also perhaps pinning it through the boom with a 1/4 inch stainless steel bolt. Finally, I ran into Keith Baker, KB1SF in Dayton and he told me he had used some wooden dowelling through his fiberglass boom so that he could tighten the U-bolt on the 40CX without worrying so much about the fiberglass cracking.

## AO-21 MOBILE

Yes there are folks working Oscar 21 from their cars. I first heard from John Sheets, N8QGC who has worked 24 states from his car via Oscar 21. He tells his own story in the accompanying sidebar.

Hank Blackstock, WA5JRH in Oklahoma is also regularly getting into AO-21 with a good signal. He is using two M2 eggbeaters. The 70 cm one is mag-mounted on the roof while the 2 meter one is bumper mounted. He runs 35 watts from a modified Kenwood 721 and has had good success. However it is unlikely that you will find him on AO-21 these days because he replaced the Kenwood with a pair of Yaseu multimodes (with 12.5 Khz steps). However you will hear him occasionally on AO-13 mobil! (Yes there is an amplifier involved).

## The Yaesu G-5400B Rotor

When I first decided to work AO-13, I bought two reconditioned Alliance U-100 rotors from a place called "Norm's Rotor Service". I had read the articles about fashioning a plate to mount the elevation rotor on, but instead I simply used its standard mounting hardware to bolt it to the mast coming out of the azimuth rotor. Essentially I just mounted it sideways. I set it up so that when the antennas were horizontal the rotor indicator pointed east. This worked fine for years, though as I got larger (unbalanced) antennas the elevation rotor indicator sometimes became misaligned with respect to the antennas. I usually pointed them for maximum signal "by ear" so this hardly mattered.

When the amateur community began to hear about the design of the microsats I knew that I was going to want to automate my station. Particularly given the weight of my then current antennas, it seemed to me that the U-100's were no longer going to make the nut. A lot of hams have faced this set of circumstances and as a result a lot of Yaesu G 5400's (and 5600's) have been sold. This rotor pair is not cheap (upwards of \$450), but it does combine azimuth and elevation rotors in the same control box which can be driven by computer if you have the KC Tracker, Trackbox, or other digital interface.

There are two ways to mount the rotors. One is to use a "separation kit" which puts a short piece of mast between the two rotors. The other is to use what used to be



an "L" bracket and is now a "U" bracket. The L or U bracket method has the distinct advantage of keeping the elevation rotor closer to the tower, tripod or other mounting device so that it is easier to get to should you need to work on it. On the other hand, some of the early models of the G-5400 had an L bracket that was weak and tended to bend (and sometimes break!). Some folks have taken to welding struts on the sides of the L bracket to increase its strength. I noticed at Dayton

this year that Yaesu had given up the L bracket approach altogether in favor of a U-shaped bracket that bolts to both sides of the elevation rotor. I inspected the one they had at Dayton fairly closely and it looks like an excellent design. I can't imagine this one giving way.

At the last couple of AMSAT Space Symposia I have overheard conversations in which satellite operators discussed replacing the grease in their G-5400's. Mine has been up for 3-4 years now and

has given me no trouble at all, but I have made some effort to investigate why some ops changed their grease and what they changed it to. That's when I ran across Mark Johns, WA0RGV. He had done surgery to his G-5400, so I asked him what he did. Here is his response, in part:

I can't remember exactly how this all worked, because it's been two years now, but as I recall, I opened the azimuth rotor of the 5400B by turning it upside down, removing the four screws that hold it all together and lifting the bottom off the top. Yes, the parts go all over if you're not careful — at least the ball bearings do — but you can put them back in any order! I wiped the bearings off with a dry cloth, which didn't remove all of the lubricant, but most of it.

I was able to get to the bearings in the elevation rotor without taking it apart. Simply remove the terminal block on one side and the sheet metal plate on the other. Again, use a dry cloth to remove as much of the original lubricant as you can.

"LubriPlate" is a product sold in many boat shops as a lubricant for the gears in outboard motors. It is VERY waterproof, and does not get stiff in the cold. It comes in a tube (about \$8 per tube), and is much thicker than the light oil lubricant original to the 5400. I just sort of squeezed it in liberally around all of the bearings. It only took about a third of the tube to do both the az and el rotors. LubriPlate is white, and the old lubricant was black, so the result was sort of light grey. I ran the rotors a bit on the bench to work it all in, buttoned it all up and put it on the tower.

The system has worked through -20°F winters and the wettest springs in recent history, including automatic operation tracking pacsats at all hours for about a year of the two years since installation.

When I was at Dayton this year I asked Chip Margelli (K7JA), Yaesu's customer service manager and Kevin Kanamanos (WD6DIH), their National Sales Manager about the grease. They said the only incidents that they had been aware of where there were rotor failures were in very low temperatures. Chip specifically recommended Lubriplate as a good grease to replace the stock goo with. When I asked Kevin whether a ham would void his warranty by taking apart his rotor and replacing the grease I was a bit surprised to hear him say that the warranty would not be voided (assuming there was no abuse of the product). So what's the bottom line on this? I guess living in western New York where we get a tremendous amount of snow but very little truly cold weather, I'm probably going to leave



| Receive Only                | Freq. Range (MHz) | N.F. (dB) | Gain (dB) | 1 dB Comp. (dBm) | Device Type | Price    |
|-----------------------------|-------------------|-----------|-----------|------------------|-------------|----------|
| P28VD                       | 28-30             | <1.1      | 15        | 0                | DGFET       | \$29.95  |
| P50VD                       | 50-54             | <1.3      | 15        | 0                | DGFET       | \$29.95  |
| P50VDG                      | 50-54             | <0.5      | 24        | +12              | GaAsFET     | \$79.95  |
| P144VD                      | 144-148           | <1.5      | 15        | 0                | DGFET       | \$29.95  |
| P144VDA                     | 144-148           | <1.0      | 15        | 0                | DGFET       | \$37.95  |
| P144VDG                     | 144-148           | <0.5      | 24        | +12              | GaAsFET     | \$79.95  |
| P220VD                      | 220-225           | <1.8      | 15        | 0                | DGFET       | \$29.95  |
| P220VDA                     | 220-225           | <1.2      | 15        | 0                | DGFET       | \$37.95  |
| P220VDG                     | 220-225           | <0.5      | 20        | +12              | GaAsFET     | \$79.95  |
| P432VD                      | 420-450           | <1.8      | 15        | -20              | Bipolar     | \$32.95  |
| P432VDA                     | 420-450           | <1.1      | 17        | -20              | Bipolar     | \$49.95  |
| P432VDG                     | 420-450           | <0.5      | 16        | +12              | GaAsFET     | \$79.95  |
| <b>Inline (rf switched)</b> |                   |           |           |                  |             |          |
| SP28VD                      | 28-30             | <1.2      | 15        | 0                | DGFET       | \$59.95  |
| SP50VD                      | 50-54             | <1.4      | 15        | 0                | DGFET       | \$59.95  |
| SP50VDG                     | 50-54             | <0.55     | 24        | +12              | GaAsFET     | \$109.95 |
| SP144VD                     | 144-148           | <1.6      | 15        | 0                | DGFET       | \$59.95  |
| SP144VDA                    | 144-148           | <1.1      | 15        | 0                | DGFET       | \$67.95  |
| SP144VDG                    | 144-148           | <0.55     | 24        | +12              | GaAsFET     | \$109.95 |
| SP220VD                     | 220-225           | <1.9      | 15        | 0                | DGFET       | \$59.95  |
| SP220VDA                    | 220-225           | <1.3      | 15        | 0                | DGFET       | \$67.95  |
| SP220VDG                    | 220-225           | <0.55     | 20        | +12              | GaAsFET     | \$109.95 |
| SP432VD                     | 420-450           | <1.9      | 15        | -20              | Bipolar     | \$62.95  |
| SP432VDA                    | 420-450           | <1.2      | 17        | -20              | Bipolar     | \$79.95  |
| SP432VDG                    | 420-450           | <0.55     | 16        | +12              | GaAsFET     | \$109.95 |

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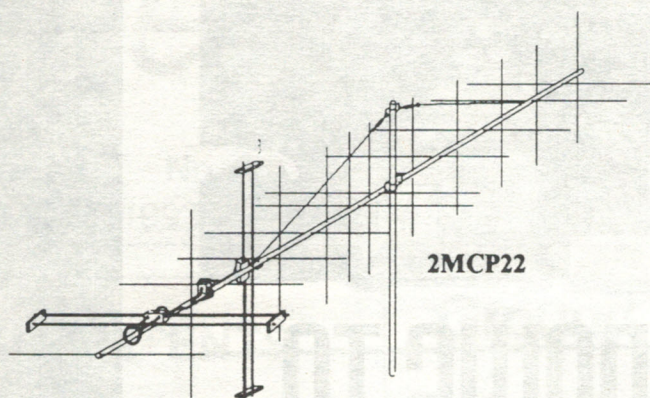
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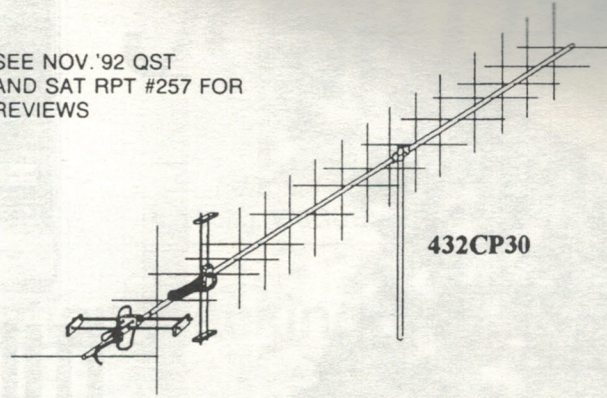


# QUESTIONS AND ANSWERS (COMMONLY ASKED)



2MCP22

SEE NOV. '92 QST  
AND SAT RPT #257 FOR  
REVIEWS



432CP30

## QUESTIONS

1. Do the feedlines have to come off near the rear of CP antennas?
2. Can I mount a metallic feedline support boom out from the main boom?
3. What is the best element orientation for CP Yagis?
4. Can I mount two 436CP30s inside my two 2MCP22s?
5. Does the 2MCP22 absolutely need a vertical boom support?
6. Why doesn't M2 provide a RHC LHC switching unit?
7. Should I use a preamp with my OSCAR system?
8. Should I mount the preamp at the antenna?
9. I Can I mount my OSCAR system up at 70 ft. above my HF Yagis?
10. What is the minimum clearance to the roof when I elevate the array?
11. What kind of feedline do you recommend?
12. Can I use my OSCAR system for terrestrial SSB/CW or FM?
13. Why should I buy the 2MCP22 when the 2MCP14 will hear the OSCAR?

If you still have questions, We will be glad to chat with you further. That is how we add even more value to the finest antennas on the market!

## ANSWERS

1. To avoid cutting the circular field that surrounds a CP antenna and disturbing the pattern and VSWR, the feed line should come off the rear.
2. Yes, Metal tubing supporting coax will have little effect on performance.
3. Any mounting works but for easiest feedline routing, the X shape works best.
4. No because the 2m antennas act like a shield and 70cm antennas suffer.
5. No, only in heavy ice conditions, otherwise it is optional.
6. We have gone for reliability by eliminating a major loss and failure area.
7. A preamp will usually improve your signal to noise ratio on 2m and 70cm.
8. For feedlines over 50 feet, antenna mounted preamps are recommended.
9. Yes but for mechanical and maintenance reasons it is not recommended.
10. The reflectors should clear the roof by 4 to 6 inches.
11. Don't Skimp here. Hardline is best but 9913 is the best bang for the buck.
12. Absolutely! and CP is sometimes very helpful on terrestrial paths.
13. You will be able to hear the 'weak ones' with the larger 2MCP22.

More detailed answers are available by phone or FAX. We could probably write a book on CP antennas!

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mine as is. But I grew up in Iowa where the temperatures have been know to hit -30F. If I still lived there I might well make the switch.

## SKED and SATSTUFF

I ran across two interesting software packages recently that I thought I would tell you about. Wayne Roth, WA2N, wrote a package for accessing the digital satellites called SKED. The unique feature of this package is that it permits automatic satellite operation with more than one satellite at a time, including priority tracking (that is if two birds are up, it picks the one you are most interested in), PB/PG configuration file switching, and processing of incoming and outgoing messages. The program itself does no tracking, but has a nice interface for both InstanTrack and QuickTrack that comes with it. Wayne posts copies of the program to the satellites as the software is updated or you can obtain a copy from me.

SATSTUFF is a very interesting program to help you understand satellite

orbits. It was written by MRJ, Incorporated as a means of advertising their engineering capabilities. It has a quite a number of nice display maps and shows satellite groundtracks and other interesting views. You can modify orbital parameters and see the effect on the satellite's orbital path. It also has a brief, but nice tutorial on keplerian elements. This program is not a satellite tracking program in the conventional sense. That is, you cannot get anything that looks like a standard ephemeris table to tell you where to point your antennas and when. The procedure needed to simply set the starting date and time is fairly cumbersome. However, if you want to experiment with a range of different satellite orbital parameters and see what the groundtrack or coverage of the satellite is or if you simply want a computer-based review of orbital parameters, this is the program for you.

All of the programs mentioned in this space for the past few months can be obtained directly from me by sending a formatted disk, a mailer and return

postage to the address at the end of this column.

Please continue to send your comments in. This is your space...a place where we can kick around ideas, tips and what have you. I can be contacted at any of the following:

On KO-23, UO-22 or other satellites when you find me on.

On Packet: WA0PTV @

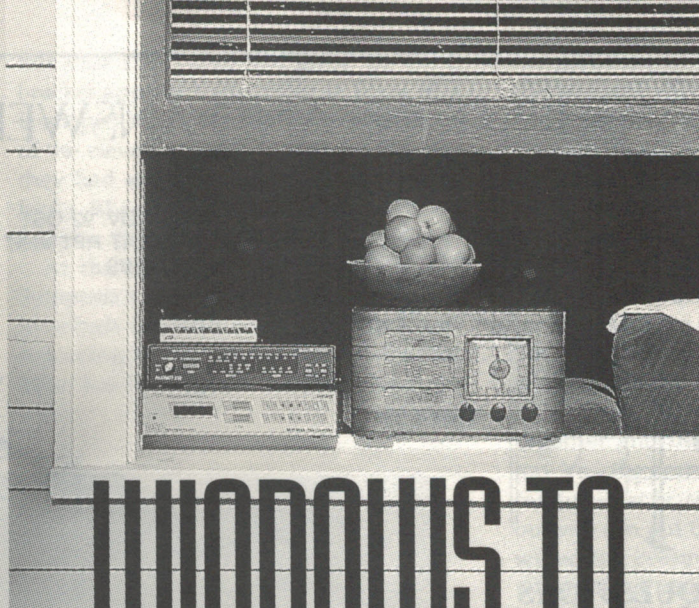
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On Compuserve: 70353,460

On Internet: hansen@jane.cs.fredonia.edu

US Mail: 49 Maple Avenue, Fredonia, NY 14063 ■





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